For Members Only
Issue 5

# MATERIALS MIND

October - December 2013

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Institute of Materials, Malaysia

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## IMTCE2014

**9th International Materials Technology Conference & Exhibition**

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13th – 16th May 2014

Putra World Trade Centre Kuala Lumpur, Malaysia

*Special Feature*

## Fingerprinting Polymeric Coatings

# IMM COURSES

| COATINGS COURSES | DURATION (DAYS) |
|---|---|
| ▪ Diploma of Applied Science (Coatings Technology) | 10 |
| ▪ Coatings Quality Control Technician (QC) | 2 |
| ▪ Blasting & Painting Supervisor | 2 |
| ▪ Corrosion Control by Protective Paint | 2 |
| ▪ Marine Painting Inspection | 3 |
| ▪ Coatings Inspection Certification Scheme | 4 |
| ▪ Protective Coatings Technician Certification Scheme | 1 |
| ▪ Thermal Spray Coatings Applicator | 2 |
| ▪ Thermal Spray Coatings Inspector | 4 |

| WELDING COURSES | |
|---|---|
| ▪ Welding Inspection Scheme | 5 |
| ▪ Associate Welding Engineer (JWES) * | 7 |
| ▪ Welding Engineer (JWES) * | 7 |
| ▪ Senior Welding Engineer (JWES) * | 8 |
| ▪ Calculation of Strength of Welded Members | 1 |
| ▪ Cost & Estimation of Welding Projects | 1 |
| ▪ Interpretation of Weld Quality by Welding Codes | 1 |
| ▪ Interpretation of Weld Quality by Radiographic Method | 1 |


| CORROSION COURSES | |
|---|---|
| ▪ Corrosion Control By Cathodic Protection | 2 |
| ▪ Cathodic Protection Technologist | 4 |
| ▪ Corrosion Technician | 4 |

| VIBRATION SPECIALISTS | |
|---|---|
| ▪ Level 1 - 4 | |

| COURSES AVAILABLE UPON REQUEST | |
|---|---|
| ▪ Blasting & Painting Course | 5 |
| ▪ Welding – SMAW, GMAW, GTAW (1G - 6G) | 5 |
| ▪ API-570 Piping Inspector | |
| ▪ API-510 Pressure Vessel Inspector | |
| ▪ API-653 Above Storage Tank Inspector | |
| ▪ Microbiologically Influenced Corrosion (MIC) | 2 |
| ▪ Management of MIC | 1 |
| ▪ Welding and Joining Technology for Non Welding Personnel | 1 |

**INSTITUTE OF MATERIALS MALAYSIA**
No. 10-1, Jalan Bandar 3, Pusat Bandar Puchong,
47160 Puchong, Selangor
Tel : 03-5882 3574/3584 Fax : 03-5882 3524
Website : www.iomm.org.my
Email : iomm@po.jaring.com

**MATERIALS TECHNOLOGY EDUCATION SDN BHD**
No. 10-1, Jalan Bandar 3, Pusat Bandar Puchong,
47160 Puchong, Selangor
Tel : 03-5882 3574/3584 Fax : 03-5882 3524
Website : www.mte.com.my
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MATERIALS MIND
October - December 2013 Issue 5

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## IMTCE 2014



## Fingerprinting of Polymeric Coatings



## Articles



## Activities






**Cover Story**
IMM and PETRONAS have initiated Fingerprinting of Polymeric Protective Coatings supplied to the Oil and Gas Industry in a same way as Mill Certificates for metals.



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No 10-1, Jalan Bandar 3,
Pusat Bandar Puchong, 47160 Puchong,
Selangor Darul Ehsan,
MALAYSIA
Tel: +603-5882 3574
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Guideline for submission of articles (Academic papers as well as Industry technical papers) can be downloaded from www.iomm.org.my

# Message from the President

As we leave 2013 and usher in 2014, on behalf of the IMM Council Members, I would like to wish all our members, friends and associates a very Merry Christmas and a very Happy New Year!

The past 3 months (October – December 2013) have been a hive of activities for the IMM working committees and regional chapters. Much focus have been placed on the Coatings Fingerprinting initiative by the Task Force comprising of representatives from the Oil & Gas Industry, Protective Coatings manufacturers, SIRIM, University academics, and Materials Testing Equipment companies. This issue of materials Mind will feature the progress of the Fingerprinting initiative and highlight the targets and deadlines for the implementation of the coatings fingerprinting certificate.

In the past 3 months, the members of the IMTCE2014 conference organizing committees have been diligently working to solicit papers, sponsors, exhibitors and advertisers for IMM's flagship event. IMTCE2014 will be held at the PWTC in Kuala Lumpur from 13-16 May 2014 and will include not only technical symposiums but also a friendly golf game for members, friends & delegates, local tours, plant visits, an exhibition, and special lectures by prominent persons from the industry and academia. For the first time internationally, IMM will bring the industry and academia together in equal force to discuss, share knowledge & experience, and to learn from each other on all things related to Materials science & engineering.

IMM continues to drive the initiative to improve quality and cost efficiency in Welding in Malaysia, particularly for the Oil & Gas Industry. IMM has been promoting the Common Welder Certification Scheme ("CWCS") and Manpower Optimization System ("MOS") in Malaysia since 2004. It has been a long journey of 10 years to educate the players in welding in the Malaysian Oil & Gas Industry that disasters loom in the industry and welding plays a significant role in the fabrication, operations and maintenance of the oil & gas facilities. Quality assurance and quality control issues are fast disappearing at worksites due to cost reduction and these can be the root causes of mishaps and incidents. This issue of Materials Mind highlights the initiative by IMM to bring the Asian Welding Federation (AWF) and the American Welding Society (AWS) to Kuala Lumpur for a round-table discussion to work together towards harmonization of welder qualification standards in Asia.

Last but not least, this issue of Materials Mind will highlight the importance of " Biomaterials " for human organ replacements and enhancement. Biomaterials is an area of importance to medical science and materials scientists play an important role to make lives better for human beings. More emphasis will be placed on Biomaterials in future publications of the Materials Mind.

On a final note, I hope our members and readers will enjoy the features and articles in this magazine. I hope members will continue to submit articles of interest to the materials fraternity and more companies will advertise in our magazine.

Wishing everyone a Happy Chinese New Year in advance and a prosperous and joyous new year ahead!

Prof. Dr. Mohamad Kamal Harun

# 2012 - 2014
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## 9th International Materials Technology Conference & Exhibition

## Conference Overview

The 9th International Materials Technology Conference & Exhibition (IMTCE2014) is scheduled to be held in May 2014 at the Putra World Trade Centre (PWTC), Kuala Lumpur.

The objectives of the conference are to:
- Provide a platform for the exchange of knowledge and expertise among industrial practitioners, industry's professionals and higher learning institutions.
- Provide a forum for discussion and exchange of views on the opportunities that arise in the challenging Material processing, and applications through collaborations between industry and academia.

With the theme of "Synergising Industry & Academia: Innovations for Industrial Applications", IMTCE2014 invites academics, scientists, engineers, researchers, industrialists and service providers to present their latest research findings in technology and innovation, and current development in Materials Sciences which include metals & alloys, polymers & plastics, rubber & elastomers, ceramics, timber & wood, concrete, minerals, nanomaterials, advanced materials, electronic materials, and textiles. We welcome you to IMTCE2014!

**Please visit our website www.imtce2014.com for full details.**

## 5 Symposiums

1. International Symposium on Advanced Polymeric Materials (ISAPM 2014)
   **Theme:**
   **Polymers and Composites as Alternative Engineering Materials**

   Symposium Co-Chairperson:
   - Assoc. Prof. Dr. Chia Chin Hua (Universiti Kebangsaan Malaysia, Malaysia)
   - Prof. Dr. Sabu Thomas (Mahatma Gandhi University, India/ Universiti Teknologi Mara, Malaysia)
   - Ms. Siti Haslina Ramli (PETRONAS Research, Malaysia)

2. International Symposium on Materials Characterisation and Testing 2014 (ISMCT 2014)
   **Theme:**
   **Technologies & Innovations in Materials Asset Integrity**

   Symposium Co-Chairperson:
   - Dr. Hasnah Abdul Wahab (SIRIM Berhad, Malaysia)
   - Eur. Ing. Nigel Brewitt (Norimax Sdn Bhd, Malaysia)
   - Dr. Andrew Spowage (Woodgroup Intetech, Malaysia)

3. International Symposium on Coatings Technology (ISCT 2014)
   **Theme:**
   **Assuring Integrity & Safety in Coatings Development**

   Symposium Co-Chairperson:
   - Assoc. Prof. Dr. Rajkumar Durairaj (Universiti Tunku Abdul Rahman, Malaysia)
   - Mr. David Lim Chee Cheong (ExxonMobil E&P (M) Inc, Malaysia)
   - Ms. Nurul Asni Mohamed (PETRONAS GTS, Malaysia)

4. International Symposium on Metallurgy and Welding Technology 2014 (ISMWT 2014)
   **Theme:**
   **Facility Safety through Welding Integrity**

   Symposium Co-Chairperson:
   - Ir. Dr. Edwin Jong Nyon Tchan (Jurutera Perunding Akal Sdn. Bhd., Malaysia)
   - Prof. Dr. A. S. M. A. Haseeb (Universiti Malaya, Malaysia)
   - Mr. M. Hasbi B. A. Razak (PETRONAS Carigali Sdn Bhd, Malaysia)

5. International Symposium on Corrosion & Material Degradation (ISCMD 2014)
   **Theme:**
   **Sustaining Technical Integrity through Improved Corrosion Protection Technologies**

   Symposium Co-Chairperson:
   - Pn. Halimah Pit (Shell, Malaysia)
   - Dr. Mahesh Kumar Talari (Universiti Teknologi MARA, Malaysia)

### SPECIAL LECTURES (14th May 2014)

1. 
   Datuk Mohd Anuar Taib
   *President – PETRONAS Carigali Sdn. Bhd.*
   *Vice President & Chief Executive Officer,*
   *PETRONAS Development & Production.*
   **Title: Cost Effectiveness in the Oil & Gas Industry– Quality & Safety Assured**

2. 
   Ir. Pramod Kumar Karunakaran
   *Vice President of Infrastructure & Utilities (Gas & Power Business), PETRONAS, Malaysia.*
   **Title: Achieving Effective Project Delivery Through A Structured QA & QC Approach**

### PLENARY SPEAKERS (14th & 15th May 2014)

1. 
   Prof. Dr. Sabu Thomas
   *Mahatma Gandhi University, India and Universiti Teknologi MARA, Malaysia*
   **Title: High Performance Epoxy Nanocomposites for Coating Applications**

2. 
   Dr. Liane Smith
   *Director of Woodgroup Intetech Ltd., United Kingdom*
   **Title: Putting Theory into Practice - Lessons Learnt from Oil & Gas Industry**

## Important Dates

| | |
|---|---|
| • Submission of Abstract | 1 Jul 2013 – 28 Feb 2014 |
| • Notification of Acceptance | 1 month after submission |
| • Submission of Full Paper/ Presentation (PDF or PPT) for CD | 1 Jan 2014 – 31 Mar 2014 |
| • Full Paper Submission for Journal | 16 May – 31 May 2014 |


*For enquiries kindly contact:*
INSTITUTE OF MATERIALS, MALAYSIA
No 10-1, Jalan Bandar 3, Pusat Bandar Puchong, 47160 Puchong,
Selangor Darul Ehsan, MALAYSIA
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## KEYNOTE SPEAKERS FOR SYMPOSIUMS (14th & 15th May 2014)

### 1. International Symposium on Advanced Polymeric Materials. (ISAPM 2014)

Prof. Dr. Abdul Kariem Arof
*Centre for Ionics University Malaya, Physics Department, Faculty of Science, Universiti Malaya,Malaysia.*
**Title: Chitosan-Based Polymer Electrolytes and Their Potential Application in Dye Sensitized Solar Cells**

Prof. Dr. Alejandro J. Müller
*1) University of the Basque Country (UPV-EHU), Spain. 2) USB Polymer Group, Materials Science Department, Simón Bolívar University, Caracas 1080-A, Venezuela*
**Title: The Effects of Confinement on the Nucleation and Crystallization of Polymer Chains**

Prof. Dr. Jas Pal Badyal
*Durham University, United Kingdom.*
**Title: Functional Nanocoatings**

Prof. Dr. Seng Neon Gan
*Department of Chemistry, Universiti Malaya, Malaysia*
**Title: Environmental Friendly Coating Resins from Palm Oil**

Dr. Kong Chin Chew
*Heads of Long Term Development Asia Laboratory, Beckers Group, Malaysia*
**Title: Sustainability in the Coatings Industry**

Dr. Mustafa Kansiz
*Agilent Technologies, Australia*
**Title: Novel Applications of FTIR & FTIR Chemical Imaging Microscopy - Simultaneous Spatial and Chemical Information at the Micron Level**

Dr. Russell J. Varley
*CSIRO, Australia.*
**Title: Novel Approaches to Sustainable Materials Development using Synthetic, Simulation and Self-healing Strategies.**

### 2. International Symposium on Materials Characterisation and Testing. (ISMCT 2014)

Prof. Dr. David Rugg
*Rolls-Royce PLC, UK*
**Title: The Industrial Application of University Based Materials Science**

Dr. Badrol Bin Ahmad
*General Manager, Performance Analyses & Diagnostics, Tenaga Nasional Berhad, Malaysia.*
**Title: Structural Integrity of Materials**

Dr. Hasnah Abdul Wahab
*Head of Joining & Inspection Services, Technical Services Division, SIRIM Berhad, Malaysia*
**Title: Failure Analysis in Asset Integrity Management**

Mr. Mohamad Azmi Noor
*Head Asset Integrity Division HSE, Asset Integrity Division, EPHSE, EVP'S Office, E&P Business, PETRONAS*
**Title: Asset Integrity Management**

Mr. Robert A. Burn
*Technical Integrity Manager, Murphy Oil Malaysia, Malaysia*
**Title: Failure of Welded Structures in the Oil and Gas Industries**

### 3. International Symposium on Coatings Technology. (ISCT 2014)

Prof. Dr. Khiam Aik Khor
Director, Research Support Office and Bibliometrics Analysis, Nanyang Technological University, Singapore
**Title: TBA**

Ms. Nurul Asni Mohamed
*Principal Engineer (Corrosion), Group Technical Solutions, Technical & Engineering Division, PETRONAS GTS, Malaysia.*
**Title: Coatings Fingerprinting**

Mr. Thomas A Jones
*SSPC, (The Society for Protective Coatings), USA*
**Title: Coatings for Asset Management**

### 4. International Symposium on Metallurgy and Welding Technology. (ISMWT 2014)

Prof. Dr. Yu-Ichi Komizo
*Joining and Welding Research Institute, Osaka University, Japan*
**Title: Status & Prospects of Advanced Structural Steel and Its Weldability**

Assoc. Prof. Dr. G. D. Janaki Ram
*Indian Institute of Technology Madras, Chennai, India*
**Title:Welding of High Temperature Alloys**

Mr. Chee Pheng Ang
*Secretary General, Asian Welding Federation, Singapore*
**Title: Welder Qualification & Performance**

Mr. Hasbi Razak
*PETRONAS Carigali Sdn Bhd, Malaysia*
**Title: Welding Inspection**

Mr. Hideaki Harasawa
*The Japan Welding Engineering Society, Japan*
**Title: Weld Integrity Analysis**

### 5. International Symposium on Corrosion and Materials Degradation. (ISCMD 2014)

Dr. Reza Javaherdashti
*Parscorrosion Consultants, Perth, Australia*
**Title: Clostridia: (perhaps) the least known corrosion-related bacteria in Industry**

Dr. T. S. N Sankara Narayanan
*Chonbuk National University, South Korea*
**Title: Controlling The Corrosion Rate of Magnesium and Its Alloys by Surface Treatments for The Development of Degradable Implants: Prospects and Challenges**

Pn. Halimah Pit
*Team Lead MCI-KL Deepwater Office, Porjects & Technology, Upstream Major Project (East), Sabah Shell Petroleum Co Ltd, Malaysia*
**Title: Corrosion Integrity**

Tuan Haji Mohd Kamal Azam Ibrahim
*Senior Manager, Materials/Corrosion Facilities Engineering Department, PETRONAS Carigali Sdn Bhd, Malaysia*
**Title: Corrosion and Materials Degradation**

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## Masterclasses

Under the auspices of 9th International Materials Technology Conference and Exhibition (IMTCE 2014)

16th May 2014
Putra World Trade Centre
Kuala Lumpur, Malaysia

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IMTCE2014 Masterclasses are a collection of scientific and technical classes/lectures of multi-disciplinary subjects, designed to cater to the industrials needs. Masterclasses cover topics related to fundamental/advanced developments and problems/solutions related to specific industries. These classes are specifically designed by professionals and experienced individuals (both international and national) in their respective fields, where participants will be able to learn, interact and discuss matters related to industrial practices.

## List of Masterclasses

| Title | Trainer | Code | Time | Fee per Person |
|---|---|---|---|---|
| 1. Performance and Fingerprinting of Epoxy Nanocomposites for Coating Applications | Prof. Dr. Sabu Thomas | MCAPM 1 | 9.00 am - 1.00 pm | RM 800.00 |
| 2. Sustainable Materials Research at CSIRO Materials Science and Engineering | Dr. Russell J. Varley | MCAPM 2 | 2.30 pm - 6.30 pm | RM 800.00 |
| 3. CRA Materials Selection | Dr. Liane Smith | MCCMD 1 | 9.00 am - 1.00 pm | RM 800.00 |
| 4. Quality Control for Coating Inspection Projects | Mr. Thomas A. Jones | MCCT 1 | 2.30 pm - 6.30 pm | RM 800.00 |
| 5. Stress Corrosion Cracking | Dr. Bryan Poulson | MCCMD 2 | 9.00 am - 6.30 pm | RM 1000.00 |
| 6. Fundamentals and Application of Rheology | Dr. David Hassell | MCR | 9.00 am - 6.30 pm | RM 1,000.00 |
| 7. Microbiologically Influenced Corrosion (MIC): Knowledge and Practice | Dr. Reza Javaherdashti | MCCMD 3 | 9.00 am - 6.30 pm | RM 3,000.00 |
| 8. How to Consistently Sustain Quality Welds During Welding Production | Ir. Dr. Edwin Jong Nyon Tchan | MCMWT | 9.00 am - 6.30 pm | RM 1,000.00 |
| 9. Coatings and Coatings Technology: Practical and Applications | Prof. Dr. Mohamad Kamal Harun/ Mr. Frankie Chua | MCCT 2 | 9.00 am - 6.30 pm | RM 1,000.00 |
| 10. Practical Fractography | Mr. Ronald J. Parrington | MCMCT | 9.00 am - 6.30 pm | RM 1,500.00 |
| 11. Cathodic Protection Technology | Mr. Kang Kim Ang | MCCMD 4 | 9.00 am - 6.30 pm | RM 1,000.00 |

1. 
Trainer: Prof. Dr. Sabu Thomas
Mahatma Gandhi University, Kottayam, Kerala, India and Universiti Teknologi MARA, Malaysia
Title: Performance and Fingerprinting of Epoxy Nanocomposites for Coating Applications

2. 
Trainer: Dr. Russell J. Varley
CSIRO Materials Science and Engineering, Victoria, Australia
Title: Sustainable Materials Research at CSIRO Materials Science and Engineering

3. 
Trainer: Dr. Liane Smith
Woodgroup Intetech Limited, United Kingdom
Title: CRA Materials Selection

4. 
Trainer: Mr. Thomas A. Jones
The Society for Protective Coatings (SSPC), United States of America
Title: Quality Control for Coating Inspection Projects

5. 
Trainer: Dr. Bryan Poulson
Newcastle University
Title: Stress Corrosion Cracking

6. 
Trainer: Dr. David Hassell
Institut Teknologi Brunei
Title: Fundamentals and Application Rheology

7. 
Trainer: Dr. Reza Javaherdashti
Parscorrosion Consultants, Perth-Australia
Title: A review of Microbiologically Influenced Corrosion (MIC): Knowledge and Practice

8. 
Trainer: Ir. Dr. Edwin Jong Nyon Tchan
Jurutera Perunding Akal Sdn Bhd, Malaysia
Title: How to Consistently Sustain Quality Welds During Welding Production

9.  
Trainers: 1) Prof. Dr. Mohamad Kamal Harun
2) Mr. Frankie Chua
Title: Coatings and Coatings Technology

10. 
Trainer: Mr. Ronald J. Parrington
P.E., FASM, IMR Test Labs
Title: Practical Fractography

11. 
Trainer: Mr. Kang Kim Ang
CorrTroL Group of companies
Title: Cathodic Protection Technology

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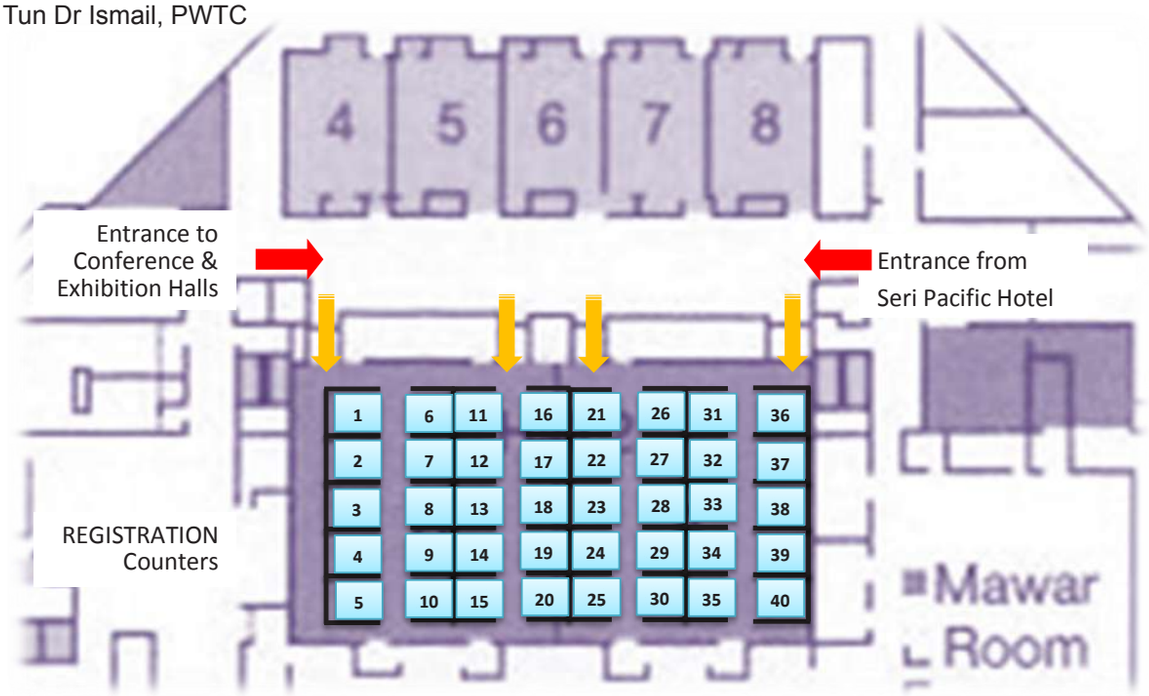


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# Coating Fingerprint Certificate

By Nurul Asni – Chairperson, IMM Task Force on Fingerprinting Polymeric Coatings

The Task Force on Fingerprinting of Polymeric Coatings has numerous working committee meetings and had conducted 2 public forums to highlight the objectives of the initiative, the first one in March 2013 (Selangor) and the second one in October 2013 (Johor) which were both attended by over 100 representatives from the Oil & Gas companies, Paint Manufacturers, Blasting & Painting applicators, Paint QC Inspectors, Engineering Consultants, Materials Testing companies, and Academicians. Following the 2nd Forum in October 2013, a draft of the "Coating Fingerprint Certificate" (equivalent to a metal's Mill Certificate) has been prepared by the Task Force for deliberation in forthcoming events and forums.

It is anticipated that this Coating Fingerprint Certificate will be finalized by end-2014 and a Specification prepared for implementation by the Oil & Gas companies in Malaysia. The 3rd Forum is planned for June 2014 which will deliberate further on the spectroscopic and physical testing methods to be incorporated into this certificate as well as the pass-fail criteria.

The Coating Fingerprint Task Force has reached an important milestone since the announcement of the initiative in the previous Materials Mind publication. It can now be concluded that Fourier-Transform Infrared Spectroscopy (FTIR) can be used to fingerprint coatings.

Among the tests conducted were as follows:

1. Feasibility and reproducibility of using FTIR for coating fingerprinting.
2. Testing fingerprint matching for pigments of similar colour, should there be any substitution in the original formula.
3. Effects on fingerprint with minor changes in coating formulation which involved extra epoxy, hardener as well as other components.
4. The effect of sun exposure with laboratory dried coating and its effect on fingerprint matching.
5. Changes in fingerprint for different priced coating components.
6. Changes in fingerprint for different shelf life coating.
7. Changes in fingerprint for different batches of coating.

The summary of the findings are listed below:

1. Fingerprints are reproducible with high matching percentage (97%) for dry finished products on test panels. Dry finished products and their wet equivalent do not produce satisfactory matching percentage values (59%). Comparisons can either be made dry to dry or wet to wet only.
2. The use of dissimilar pigments if different to the original formulation will give a significant fingerprint.
3. Changes in coating component's composition were also tested such as additional 5% epoxy, 5% Polyamine, 5% Aluminium as well as other components. Changes in fingerprint absorption bands can be observed where the intensity of the absorption bands was increased. This also indicated that a reduction in compositions will lead to reduction of the intensity of the absorption bands.
4. A short term test using panels under sun exposure of 2 weeks were compared with laboratory applied coating (freshly dried) and no significant differences (89%) in the fingerprint absorption bands were observed. This finding could be considered as a potential testing protocol of verifying coating quality after application, within a stipulated timeframe.
5. It is interesting to note that different pigment and epoxy qualities will produce different fingerprints and the matching percentage becomes smaller with significant quality difference. A small difference in price produces a matching percentage of 75% where as a large variation in price produces a matching percentage of only 6%.
6. The fingerprints of relatively fresh coatings of 3 months were compared to those that are over 2 years of shelf life and a significant difference (49%) was detected.
7. Generally, the fingerprints of hardeners do not change much for different batches. The correlation for different batches of epoxy will require further testing.

Members of the task force from paint manufacturers such as PPG, PLC, Hempel, Jotun, International Paint, Kansai, Akzonobel and KCC will continue to support this initiative by providing samples to determine realistic acceptance criteria for different batches of epoxy fingerprints. For the purpose of the exercise by the Task Force, the FTIR tests will be conducted by the equipment suppliers, Research Instrument, Agilent and Perkin Elmer. Subsequently, it is expected that the paint manufacturers will purchase their own FTIR equipment and train their laboratory technicians to conduct the tests during each paint production batch.

A quick recap of the Task Force objectives:

1. To review the available standards and specifications requiring Fingerprinting of Polymeric Coatings in the Oil & Gas Industry.
2. To review quality control and quality assurance techniques practiced by the paint manufacturers during manufacture and storage.
3. To review QA and QC techniques practised by the blasters & painters in regards to the paints prior to application and during application
4. To review fingerprinting testing methods available in regards to the reliability, speed of testing and costs.
5. To establish a Fingerprinting Document Template acceptable to all parties involved in the manufacture, application and usage of Polymeric Coatings in the Oil & Gas Industry.

The next milestone will be the establishment of a Coating Fingerprint Certificate template by May 2014. The subsequent steps involve the internal discussions within the Oil & Gas operating companies on procedures and possible implementation as well as Task Force roadshows to IMM fraternities.

# Fingerprinting Forum II in Johor

The IMM Polymer Committe along with the IMM Coatings Committee, supported by the Malaysian Offshore Contractors Association (MOCA) and the IMM Southern Chapter conducted a half-day forum at Tanjung Puteri Golf Resort, Johor, titled "Towards Fingerprinting of Polymeric Coatings II", which served as a follow-up to the highly publicized first Fingerprinting Forum that took place earlier this year.

The event fell on Friday, 11th October 2013 and was sponsored by Hempel, Kansai Nerolac Paints, Agilent Technologies and Research Instruments Sdn. Bhd. The consecutive series of Fingerprinting Forums serve as a means for academicians and industry experts to discuss the innovative concept of "fingerprinting" polymeric coatings, in order to confirm their consistency and durability.

The 2nd Fingerprinting Forum drew a considerable number of participants, with more than 100 in attendance. The forum comprised of a total of 4 presentations by Professor Dr. Mohd Kamal Harun, President of IMM and Deputy Vice-Chancellor of University Malaysia Kelantan, Mr. Frankie Chua, founder and Managing Director of PLC Laboratories Sdn. Bhd., Mr. Muhammad Hawari Hassan of PETRONAS Malaysia, and Ms. Renee Teo of Research Instruments Sdn. Bhd.

Prof. Kamal spoke on "Fingerprinting of Polymeric Coatings", and highlighted the new method of fingerprinting paint, briefly outlining the process. According to him, a relatively expensive higher grade paint will perform better in the long run than a lower grade paint that costs relatively less.

Mr. Frankie Chua discussed the process of paint production, describing it as "the act of blending together ingredients in order to produce a mixture that is applicable, as well as faithful to its intended purpose." Mr. Chua encouraged the audience to seriously consider the method of Fingerprinting as a viable and universally applicable means of ensuring the durability and integrity of paint supply in the future.

Mr. Muhammad Hawari Hassan stressed the importance of adopting alternative coating control methods, citing the various paint failures as a key incentive for this. He ensured the audience of PETRONAS's stringent quality control of its paint supply, which must go through a rigorous series of tests in order to ensure its high standard of performance.

Ms. Renee Teo Yong Yin of Research Instruments Sdn. Bhd. Spoke on "FTIR Application in Paint Distillation". She spoke on FTIR, which is a powerful analytical technique that enables its user to identify and evaluate chemical changes of polymeric coatings, and in turn cross-checks the quality of finalized products and serves in the failure analysis of coating systems. A demonstration of FTIR was conducted by Ms. Teo after her presentation, which was carefully observed by the enthusiastic participants.

The presentations were followed by an open discussion. Many important points were brought up and addressed, resulting in a stimulating and productive exchange between speakers and participants. The Chairperson of the Coatings Fingerprinting Task Force Ms. Nurul Asni Mohamed of PETRONAS gave a summary of the task force activities and presented the draft of the Coatings Birth Certificate.

The forum concluded with the Chairperson of the Polymer Committee expressing her heartfelt appreciation for the efforts of the organizers, as well as the speakers and participants for enabling the event to be a smooth-sailing and fruitful affair. She also cordially encouraged the audience's participation in the upcoming 3rd Fingerprinting Forum, which will take place in 2014.

The forum concluded with the participants expressing a strong interest in the consecutive Fingerprinting Forum. Besides highlighting the necessity for the Malaysian Oil and Gas Industry to adopt a new method of quality control, it also instilled into participants the strong possibility of Polymeric Coating Fingerprinting as a solution to this issue.




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Towards Fingerprinting of Polymeric Coatings II


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# Fingerprinting Forum Rapporteurs Report

**COATINGS FINGERPRINTING TASK FORCE FORUM NO.2**

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| Date | 11th October 2013 |
| Time | 2:30pm - 6.00 pm |
| Venue | Tanjung Puteri Golf Resort, Pasir Gudang, Johor. |
| Jointly organised by | IMM Polymer Committee & IMM Coatings Committee. |
| Co-organized by | Malaysian Offshore Contractors Association (MOCA) &IMM Southern Chapter. |
| Participants | 105 representatives from Hempel, Shell, Petronas, MMHE, KCC Paint, Jotun Paint, Kansai Paint, PPG, MOCA, ETC-CP, Sea Horse Service, UiTM, UKM, UTM, (Revision needed) |
| Co-sponsored by | 1. Hempel (M) Sdn. Bhd. |
| | 2. Kansai Coatings Malaysia Sdn. Bhd. |
| | 3. Research Instruments Sdn. Bhd. |

**Introduction**

Many years ago, the Oil & Gas industry discussed the idea of establishing a QA/QC system to check on the quality of polymeric paints supplied to the oil & gas industry. There were concerns regarding the cost reduction initiatives - that paint manufacturers may supply “cheapened formula” products labeled as the actual high quality products which was approved by the oil companies. Scientific testing technologies were not available then for the protective coatings to be “fingerprinted” like metals & alloys, which can be checked against its mill certificates obtained via spectrometers and in-house laboratory QC tests. The idea naturally died off. It is believed that the oil & gas industry continues to be plagued with supply of non-conforming protective coatings due to fierce price competition. Material testing technologies have advanced exponentially over recent years that it may be possible for polymers to be “fingerprinted” in the near future.

This was the second in the series of such forums, as the initiative towards “Fingerprinting” technology for polymeric coatings will require many rounds of discussion amongst interested parties. The forum is aimed at dispelling the notion that there is no way to fingerprint the polymer coatings on the steel structures & pipelines in oil and gas industry. The first Forum of “Towards Fingerprinting of Polymer Coatings” held on 22th March 2013 by Institute of Materials, Malaysia (IMM), had sent out the clear message that there are ISO standards for fingerprinting of the polymer coatings and most importantly, the users are urging the paint manufacturers to provide “Mill Certificates & QC test reports” for the products supplied in order to ensure conformity of the approved specifications.

This forum was attended by 105 participants from the oil companies, fabricators, paint manufacturers, blasting & painting contractors, scientific instrument specialists, academicians, paint suppliers, researchers and university students.

**Summary of the presentation sessions:-**

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| Speaker 1 | Prof. Dr. Mohamad Kamal Harun, Universiti Malaysia Kelantan and Universiti Teknologi MARA |
| Topic | Chemical Analysis Approaches in Polymeric Coating Identification |

The objective of this presentation is to provide the audience with knowledge of the components of an epoxy coating in regard to the resin, additives, solvents and curing compounds. The presentation is aimed at providing information on the many possible types of components of an epoxy coating ranging from a lower quality grade to a higher quality grade component. In essence, this presentation will highlight that an epoxy coating can have many grades of formulation and yet look and smell the same, even though the quality is different. In other words, like stainless steels, they all look alike and unless there is a method of scientific fingerprinting the product, one cannot tell if the product is the same as its original formulation.

The speaker introduced basic paint constituents and elaborated possible mechanisms of paint failure. He mentioned that the main challenge to overcome coating failure is to improve/increase polymer ionic resistance. Study shows that out of six properties of good quality paint, five are closely related to the properties of binder as follow:

- Good wetting properties (binder)
- Good adhesion on wet or dry substrate (binder)
- Low H2O, O2 and ionic permeability (binder)
- Minimize internal stress
- Good neutralization of chloride and sulfate salts (binder)

- High electrical resistivity to isolate cathode and anode (binder)

He described on basic principles of FTIR by giving some example how IR spectra can differentiate polymer products with different chemical components/functional groups. He also concluded his presentation stating that there is possibility to fingerprint a basic polymeric resin using FTIR and the data may help purchasers to determine the quality of products received.

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| Speaker 2 | Mr. Frankie Chua Cheng Huat , PLC Laboratory Sdn. Bhd. |
| Topic | Production and Quality Control of Paint |

The objective of this presentation is to highlight to the audience that the paint manufacturers carry out batch quality control testing on every batch of products produced in their factory on a daily basis. Thus, every batch of paint manufactured has its own batch quality control test report containing results of density, viscosity, hardness, opacity, pigment-volume-concentration, volume solids, thixotropy, etc. Such test results can be provided by the paint manufacturers to their customers at no extra costs as they are part of the batch QC tests conducted daily. Currently, paint manufacturers do not provide such QC test reports to their customers. These test results can be part of the fingerprinting document in addition to the FTIR results. The FTIR or other spectroscopic testing will be a new QC process for the paint manufacturers and the costs of such tests can be determined from the cost of the equipment amortized over the life of the equipment against the number of tests to be conducted over its life-time. The paint manufacturers' existing technical staff can be trained by the equipment suppliers on how to operate the equipment while the paint manufacturers' chemists can be trained to interpret the results.

The speaker introduced paint basic compositions (as listed below) that are blended homogenously

- Solvent/water
- Resin/binder – binds all elements in the product and provides adhesion to substrate
- Fillers/pigments
- Additives – in small quantities to achieve certain traits of the product

He shared on the paint manufacturing process flow and testing conducted throughout the manufacturing process. Physical properties, including specific gravity, density, rheology, opaque, and colour, are the main concern in the paint production currently. Rejected batches may be subjected to further formulation adjustment to achieve the acceptable criteria for intended purpose. He concluded that every course of production is checked for quality assurance and goes through standard quality assessments

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| Speaker 3 | Mr. Muhd Hawari Hassan, PETRONAS GTS Dept |
| Topic | Qualification for New Maintenance Painting System and Products for Offshore Application |

The objective of this presentation is to highlight to the audience that despite so much attention being emphasized on the surface preparation and QC inspection, the number and degree of paint failures in the Oil & Gas industry continues to be a serious & costly issue. In the 1970s & 80s, the blame for paint failures fell primarily on the blasters & painters who are from low education background. So, the painting industry conducted training & certification programs for the blasters & painters as well as Paint Inspectors to improve quality control. Blasters and painters were blamed for not consistently achieving good blasted surfaces to minimum SA 2.5 quality. Nevertheless, paint failures continue to plaque the industry. So, in the 1980s, the Steel Structures Painting Council (SSPC-USA) promoted an initiative to paint manufacturers to research & develop surface-tolerant coatings. The major paint manufacturers such as International Paints, Ameron, PPG, Hempel and Jotun developed surface-tolerant epoxy coatings which performed excellently on not-so-well prepared surfaces such as SA 2 quality or lower quality standard. Such surface-tolerant epoxy coatings exhibited performance of more than 10 years on not-so-well prepared surfaces. Then, in the 1990s, due to stiff competition amongst the paint manufacturers, paint failures became common again. The Oil & Gas companies in Malaysia and other countries focussed on training and certification of blasters & painters again. In Malaysia, the IMM Blaster & Painter Certification Scheme was specified by Petronas in their Petronas Technical Standards (PTS) for Painting in 2000. At that time, IMM proposed to establish a "Mill Certificate" for the coatings as well but due to lack of available spectroscopic testing technologies, the idea was abandoned.

The speaker started his presentation by explaining real-life situations of how corrosion on offshore oil-rig topside facilities has been devastating with some coatings failing after six months of application. Due to this issue, PETRONAS has looked into application and surface preparation of external coating extensively to resolve one aspect of this problem. PETRONAS is looking seriously into coating issues and trying to cover all possible aspects. Since 80's, PETRONAS has looked into surface preparation and application and even now they are deliberating possible ways of minimizing failures arising from surface preparation and coating application. Aiming at effective, best solution for reduction of downtime, in-service application and flexible technical requirements for better result, PETRONAS GTS with collaboration from SIRIM and Petronas Carigali have encouraged paint manufacturers to propose new methods/options in coatings technology which can perform better and reduce maintenance cycles.

To compliment this effort, the Speaker highlighted that Fingerprinting using FTIR or other spectroscopic technologies is a serious consideration by PETRONAS to ensure the product received is as per specification.

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| Speaker 4 | Ms. Renee Teo Yong Yin, Research Instruments Sdn. Bhd. |
| Topic | FTIR Application in Coating Industry. |

The objective of this presentation is to demonstrate to the audience that FTIR method can be used successfully to

provide a fingerprint for polymeric materials such as paint. There had been concerns that the FTIR method will be a tedious, time-consuming and complicated method requiring highly skilled technicians and chemists to conduct the test and interpret the results. There had also been concerns that the results will not be reproducible and accurate. There were also concerns that the equipment will be bulky and expensive.

The speaker started her presentation by briefly introducing the components of a paint. She explained how FTIR can identify paint contents by looking at few parameters from the spectrum, such as intensity, absorbance peaks, and wavenumbers. FTIR is possible for fingerprinting of raw material identification and even can be used for QA/QC and failure analysis. With current technology, FTIR is a good tool for identification which takes minimal time consumption and high repeatability. The new sampling technique which is ATR (Attenuated Total Reflectant) sampling technique sounded amazing to the audience. ATR sampling technique needed hardly any sample preparation before analysis, fast cleaning steps and has the benefit of low maintenance cost. She concluded the presentation with a demonstration of fingerprinting of primers and hardeners as well as finished goods of epoxy coatings. The demonstration session successfully showed to all participants how the FTIR instrument can generate IR spectrum within a minute with high repeatability and minimum sample preparation. The identification of the raw materials and detection of the different grades of end product had caught audience's attention. The audience was keen to know more about the capability of FTIR.

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| Speaker | Ms. Nurul Asni Mohamed, Fingerprinting Task Force Chairman |
| Topic | Taskforce Update on Coatings Fingerprinting |

The objective of this presentation is to inform the audience of the progress of the Fingerprinting Task Force activities since its formation in April 2013 after the 1st Forum was initiated by IMM in March 2013 and the roadmap of the Task Force to complete its task and implement the Fingerprinting requirement for the industry. The Task Force had held a number of meetings which included practical sessions using the FTIR equipment to conduct tests on various paint samples to determine the sample preparation time, test time, results reporting time, accuracy of the results, reproducibility of the results, differentiation of results of different test samples, and identification capability. The Task Force also looked into the costs of the equipment, its operating costs and also availability of portable equipment for in-situ testing on-site. The Task Force will eventually establish a Fingerprinting Template which will contain all the essential QC elements required for the "Fingerprint" of a paint product.

The speaker informed on the establishment of the Fingerprinting Task Force Team that will look up into the fingerprinting implementation. The Task Force team is still discussing the scope of tests to be included and testing methods. The milestone and deliverables were explained which is looking at pilot execution in 2014 and possible deployment in 2015. The first draft of the Fingerprinting "Mill Certificate & QC test report" (Template) was presented to the audience.

**Q&A Session**

Q1. Ir. Max Ong (IMM) asked the presenters whether FTIR spectra can tell the difference between a low quality and a high quality epoxy. Prof. Dr. Kamal Harun explained that FTIR can only differentiate the different type of epoxy, in term of chemical functional groups, instead of the cost or quality.

**The Task Force Committee will review the availability of technical libraries of low grade and high grade epoxy resins in the industry. Such libraries will provide useful reference for the industry to conduct quality assurance and failure analysis studies.**

Q2. Mr. Frank Wright from Sabah Shell PC raised the concerned about where the fingerprinting is going to deployed and can this FTIR method define the minimum-maximum range or envelope that can be adhered to. Ms. Nurul Asni explained that the task force committee, comprising paint users including the PSCs, manufacturers and academics, are still discussing the scope of deployment and the acceptance criteria of the test.

**The Task Force Committee will initially establish the quality requirements for the production of paints in the factory similar to the Mill Certificate requirement for metal products which is a quality document produced by the steel mill during the production of its product in the factory. In-situ site quality analysis using advanced FTIR equipment will be considered subsequently.**

Q3. A paint manufacturer representative asked about the quantity/frequency of the products in normal production to be analysed for the fingerprinting purposes? Ms. Nurul Asni answered that the fingerprinting has yet to be implemented and it is in plan for deployment in the near future and the plan is to have every batch of production to undergo the tests.

**The Task Force Committee recommends that every batch of production shall be tested and provided with the Fingerprinting Birth Certificate.**

Q4. Dr. Chan Chin Han from IMM asked the presenters about the current practice whether is there any certification/documents to ensure products supplied are as per contract spec. Ms. Nurul Asni explained that currently the paint manufacturers provide a Certificate of Quality without fingerprinting information when they supply the paint to the site. As such, currently, the customer has no means to identify if the product supplied is the product ordered in terms of product formulation and quality.

**The Task Force Committee intends to finalize the format of the Fingerprinting Birth Certificate and present it**

**during the next Fingerprinting Forum scheduled in June 2014 in Kuala Lumpur.**

Q5. Dr. Chan Chin Han also asked the opinion from Mr. Muhd. Hawari about how beneficial a fingerprinting certificate in quality control and monitoring between different supplied paints will be for PETRONAS and other oil companies. Mr. Muhd Hawari explained that, with current practise, sampling/audit can be done anytime according to the clause listed in PTS to check on the quality of a paint product should there be failures on a project during application. The supplier will be blacklisted if they failed the audit. However, he acknowledged that only physical tests can be conducted on the product supplied and the current testing methods cannot fingerprint the product to its original formulation.

**The Task Force Committee will identify all the necessary physical, chemical and spectroscopic testing methods to be conducted by the paint manufacturers for every batch of production and discuss them during the next Forum.**

Q6. A paint manufacturer's representative raised the concern about revealing of the paint formulation if paint fingerprinting is implemented. Dr. Chan Chin Han from IMM explained that it is not the intention of Fingerprinting to intrude into the paint formulation. The paint manufacturers' product formulation will remain a secret as FTIR analysis will not be able to expose the product formulation. FTIR will be able to match a graph of the newly produced product to the original product with an accuracy of >90%.

**The Task Force Committee assures paint manufacturers that the Fingerprinting initiative is not aimed at identifying the secret formulation of the paint product. Fingerprinting test methods will offer customers with quality assurance that what they bought is what they will get, even though they cannot know what are inside the product formulation.**

Q7. Mr. Mohd Asyraf from MMHE raised a concerned about the price factor in securing a project and how does the implementation of fingerprinting assist the paint manufacturer. Dr. Chan Chin Han explained that the fingerprinting is for quality assurance. It should be viewed as an initial investment of a project. Ir. Max Ong highlighted that the 2 equipment suppliers (Research Instruments and Agilent Technologies) have indicated that the laboratory-scale FTIR equipment costs around RM100,000.00-RM150,000 while the portable FTIR unit costs slightly more and the equipment can perform for 10 years. When amortized over 10 years in a paint manufacturing factory which produces say, 2 batches of 1,000 litres of paint each day (average of 40 batches a month = 40,000 litres a month i.e 4.8 million litres in 10 years), the cost of the FTIR testing equipment works out to be 3 sen per litre of paint produced, excluding the costs of operation, consumables & maintenance.

**The Task Force Committee acknowledges that the FTIR testing costs may vary from one paint manufacturer to another due to the volume of products manufactured in a year. Nevertheless, the major reputable paint manufacturers of high quality products with the larger volume of production will have a very insignificant increase to their production costs. The impact will be higher on the smaller paint manufacturers who do not produce the higher quality products. The Task Force Committee will also embark on initiatives to offer training programs for operations and interpretation of the FTIR equipment through the IMM so that the currently-employed staff of the paint manufacturers can be trained to carry out their new job scopes.**

Q8. Mr. Sumardi from Sarawak Shell asked about who should be the body to prepare the Birth certificate and whether there will be monitoring by a third party. Ms. Nurul Asni answered that the actual implementation is yet to be finalized.

**The Task Force team will discuss on the mechanism of implementation in the forthcoming meetings. The 3rd Fingerprinting Forum scheduled in July 2014 will highlight further progress of the Task Force towards implementation of the Fingerprinting exercise. The Fingerprinting process shall follow the practice of the metals industry for the Mill Certificate where the manufacturer takes the responsibility to prepare the Mill Certificate for the product manufactured in their factory. The customer has the right to conduct a third-party quality control inspection in the manufacturer's factory to ensure compliances.**

Q9. Dr. Chia Chin Hua, the forum chairperson, asked opinion from Mr. Muhd Hawari about the usefulness of FTIR fingerprinting of polymer coating materials in the supplier selection process. Mr. Muhd Hawari explained that the selection is carried out in many angles; among others are application methods and product quality. Having FTIR, it will play its role in the later process of the purchase and may as well impact the selection process.

**The Task Force Committee will establish Fingerprinting specifications for the Oil & Gas industry to adopt for their paint products pre-qualification and selection process. Such a specification will assist the oil & gas industry to improve its quality assurance program in ensuring the effective corrosion protection of its facilities onshore and offshore in severe corrosive environments. It will also ensure that the quality of the anti-corrosion paint products supplied throughout the qualification period will not be compromised and changes to the product quality can be detected prior to application.**

# Fourier-transform infrared analysis of polymeric coatings as benchmark for paint industry

**CHAN** Chin Han[1*] and **TEO** Yong Yin[2]
[1]Universiti Teknologi MARA, Faculty of Applied Sciences, 40450 Shah Alam, Selangor, Malaysia
E-mail: cchan@salam.uitm.edu.my and cchan_25@yahoo.com.sg
[2]Research Instruments (M) Sdn. Bhd., D7-1-G, Block D7, Pusat Perdagangan Dana 1, Jalan PJU 1A/46, 47301 Petaling Jaya, Selangor, Malaysia
Email: renee.teo@ri.com.my

**Abstract**
Major oil and gas companies in Malaysia are calling for fingerprint certification for the supply of polymeric coatings from local paint manufacturers as quality assurance requirement of the coatings supplied. This will reduce the possibility of failures of the polymeric coatings, which lead to the corrosion of steel structures. Local paint manufacturers are refraining from certification of polymeric coatings due to trade secret of their paint formulations and lack of knowledge on modern analytical methods. Since materials testing technology, particularly on polymeric materials, have improved significantly over the past decade, it is now possible to fingerprint polymeric coatings by simple FTIR analyses. Single-component systems (the color organic pigment) and multi-component systems (the epoxy paints) were studied. The four yellow color organic pigments as well as the two epoxy paints [consist of two parts for each epoxy paints, i.e. epoxy resin (or base) and hardener (or curing agent)] have similar physical appearance by merely visual inspection. By referring to the fingerprint region of the FTIR spectra, different chemical structures of the four yellow color organic pigments and different paint formulations of the two epoxy paints can be concluded.

**Introduction**
Each year, oil and gas companies spend billions of dollars on polymeric coatings for steel structures. The existing problem of oil and gas companies faced in Malaysia for on-site jobs of polymeric coatings on steel structures is that the quality of polymeric coatings varies from job to job for the same product brand from the same supplier or paint manufacturer. This can be due to the inherent problem of the reformulation of polymeric coatings or in other words adulterated polymeric coatings are supplied, where the quality of the coatings deviates from the submitted specifications for prequalification and tender purpose. The frequent failures of the polymeric coatings due to poor quality of adulterated polymeric coatings supplied has led to severe inventory loss to the companies and serious threat to the environment and also caused many safety issues to plant personnel and surrounding public [1-2].

As mentioned in ref. [3], the application of analytical techniques for fingerprinting of polymeric coatings [4] from local paint manufacturers is slow to be accepted as standard practice due to the concerns of formula trade secret, high investment costs of the instruments, finding or training suitable personnel to use the instruments since a certain amount of knowledge and expertise are required in order to be able to correctly analyze and interpret the data generated by these instruments [5-6].

The process of paint manufacturing is covered from the raw materials to the finished product including the in-house production quality control tests. Paints or polymeric coatings are essentially made up of the polymer resin, additives (including pigments, extenders, fillers, property-modifying agents etc.) and solvents. The production quality-control tests include viscosity, solids, specific gravity, opacity, finess-of-grind, pigment-volume-concentration, adhesion test, pencil hardness test, color etc are performed in the in-house laboratory during the paint manufacturing process [7]. Special tests such as the salt-fog test, cathodic disbondment test, chemical resistance tests etc are carried out upon the request by the customers, and generally are a one-off test carried out by a third-party laboratory. No spectroscopic testing has been carried out on polymeric coatings to-date.

Infrared (IR) spectroscopy has long been a valuable tool for identifying organic functional groups by virtue of their characteristic vibrational frequencies. Radiation in the IR region will cause stretching and bending vibrations of the bonds in most covalent molecules of organic compounds. IR is one of the oldest of the spectroscopic methods used in polymer science for identification of chemical structures. In principle, when IR radiation passes through a sample; some of the IR radiation is absorbed, and the rest is transmitted. The resulting spectrum represents the molecular absorption and transmission, creating a molecular fingerprint of the sample. In short, no two unique molecular structures will produce the same IR spectrum.

As mentioned in ref. [3], two related ASTM standards on Fourier-transform infrared (FT-IR) are currently available for quality control of polymeric coatings [8-9]. The first and older standard, ASTM D2621-87 (2011), involves the separation of the different components of paint (solvents, binders, pigments) via high-speed centrifuging. The separated components are then analysed individually. The analysis requires the careful and consistent application of a uniform thin film of the separated components onto a NaCl window [3].

The second and relatively recent standard, ASTM D7588-11, does not require the separation of the paint components. However, it requires the availability of attenuated total reflectance (ATR) accessory to be attached to FTIR. The complete paint formulation is analyzed, including the solvent or with complete solvent evaporation. Hence, revelation of product formulation of the paint product by FTIR analysis is technically challenging. Sample preparation is simple and convenient. The FTIR analysis requires minimal operation time and operator skill. This method appears to be similar to one reported much earlier [10]. However, there is lack of guide in ASTM D7588-11 and ASTM D2621-87 for the interpretation of FTIR spectra, i.e. the practical approaches on estimation of the degree of similarity between two FTIR spectra for the same or different polymeric coatings.

The objective of this study is to reveal the simplicity of sample analysis by FTIR and interpretation of results with the assistance of FTIR software for raw material of the polymeric coatings (or paints) (i.e. the color organic pigment in this case) as well as the epoxy paints. Although numerous FTIR tests were carried out on various epoxy coating samples and color pigment samples, this paper highlights the results of the FTIR tests on selected samples.

**Experimental**
***FTIR sample collection***
The color organic pigments were supplied by local Paint Manufacturer 1 and the epoxy paints were kindly provided by local Paint Manufacturer 2. These samples were analyzed as received.

***FTIR analysis***
FTIR analysis was carried out on the as received samples by using the Attenuated Total Reflection method (ATR) on Nicolet iS5 (Madison, USA). FTIR spectra were recorded in the transmittance mode over the range of 600 - 4000 $cm^{-1}$ by averaging 32 scans at a maximum resolution of 4 $cm^{-1}$. The material of ATR crystal was Diamond coated with ZnSe germanium. The spectra of FTIR were analyzed by OMNIC Software Suite (Madison, USA).

***Quality control of the samples***
Absorbance spectra were baseline corrected. FTIR spectrum of one of the samples within one set of experiment was adopted as the reference spectrum. The degree of similarity, which is termed as *correlation (r)*, of a spectrum was generated by comparing the spectra of the sample to that of the reference using the QC Compare function of the FTIR software. Quantities *r* (from 0 to 1) were estimated firstly for spectrum with wavenumbers from **i)** 650 - 4000 $cm^{-1}$, and subsequently from **ii)** 650 –

1700 $cm^{-1}$. Degree of similarity is directly proportional to quantities of *r, i.e.* $r = 1$ represents complete matching of the sample spectrum to that of the reference spectrum.

## Results and discussion

### *Color organic pigment of polymeric coatings*

Color pigments are one of the common raw materials for coatings industry. Organic pigments, which can be fingerprinted by FTIR, are commonly used. Four yellow color organic pigments were supplied, which were labeled as Yellow Pigments 1 to 4. All the four yellow pigments display high similarity (see Figure 1) in term of color and it is hard to be differentiated by merely visual inspection.

FTIR spectrometer measures the frequencies at which the sample absorbs the IR radiation and the intensities of the absorptions. Determination of these frequencies allows the identification of the possible chemical structures of a sample. This is due to the chemical functional groups are known to absorb IR radiation at specific frequencies. Figure 2a depicts the four FTIR spectra for all the four yellow pigments (whole FTIR region). The characteristic vibrational modes exhibit by Yellow Pigments 1 to 4 are obviously found to be different, especially for the wavenumber in the range of 650 to 1700 $cm^{-1}$ (the fingerprint region, refer to Figure 2b). The differences can be unequivocally described by absorption band shapes, band intensities and in other band properties. In short, all the 4 yellow pigments possess different chemical structures but all display similar yellow color.

Yellow Pigment 1 was randomly selected as the reference FTIR spectrum in this study. The degree of similarity *(r)* (in term of chemical structure), of Yellow Pigment 2 to 4 were generated by comparing the spectra of the sample to that of the reference spectrum using the QC Compare function of the FTIR software. Quantities r were estimated firstly for spectrum with wavenumbers from i) 650 - 4000 $cm^{-1}$ (the whole spectrum), and subsequently from ii) 650 – 1700 $cm^{-1}$ (the fingerprint region); and are tabulated in Table 1. For the whole FTIR region and fingerprinting region, quantities $r \leq 0.22$ are noted for Yellow Pigments 2 to 4 as compared to Yellow Pigment 1 (the reference). In other words, the chemical structures of Yellow Pigments 2 to 4 are essentially different from Yellow Pigment 1, which can be revealed easily by simple FTIR analyses and estimation of quantities *r* using the QC Compare function. In principle, QC Compare function is available for all FTIR spectrometers from different manufacturers.

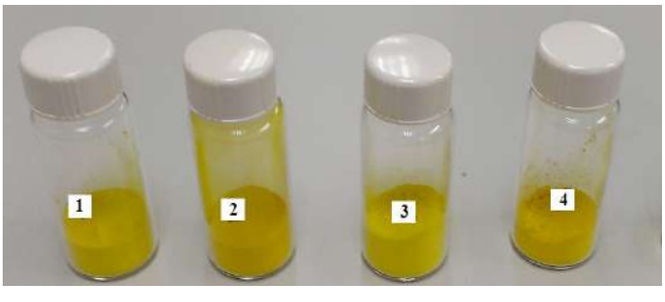


**Figure 1** Yellow Pigments 1, 2, 3 and 4 which display high similarity in term of color

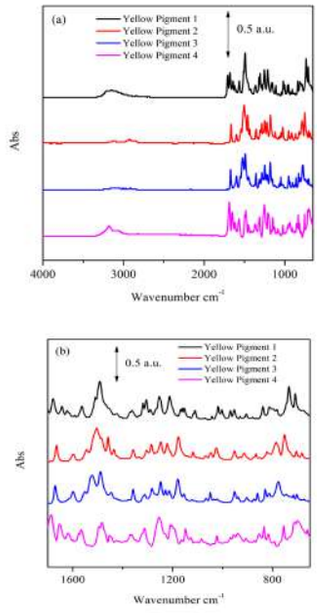


**Figure 2** FTIR spectra of Yellow Pigments 1, 2, 3 and 4 for **a)** whole region and **b)** fingerprint region

**Table 1** Degree of similarity (r) for Yellow Pigments 1, 2, 3 and 4

| **Sample** | ***r*** **650 - 4000 $cm^{-1}$** | ***r*** **650 - 1700 $cm^{-1}$** |
|---|---|---|
| Yellow Pigment 1 | reference | reference |
| Yellow Pigment 2 | 0.035 | 0.035 |
| Yellow Pigment 3 | 0.083 | 0.083 |
| Yellow Pigment 4 | 0.22 | 0.22 |

### *Polymeric coatings*

After the FTIR fingerprinting on the single-component systems (the color organic pigment), now multi-component systems (the epoxy paints) are discussed in this subsequent section. In general, paints consist of a few basic components (e.g. solvent, resin, filler, pigments, additives), that are mixed homogenously. Epoxy paints, which are always supplied to the job sites in the form of two parts, i.e. epoxy resin (or base) and hardener (or curing agent) were analyzed. Two epoxy resins were labeled as Epoxy 1 and Epoxy 2 and analogue labels for hardeners. Epoxy 1 and Epoxy 2 (as well as Hardener 1 and Hardener 2), which are claimed to provide similar performance as required but with the price differences of roughly 30-60%.

Similarly to the four yellow organic pigments as discussed previously, where by visual inspection, these two epoxies and two hardeners have similar physical appearance. Without the intrusion of the paint formulation, the FTIR spectra of the two hardeners reveal the dissimilarity of the paint formulation for these two hardener samples, but further interpretation of FTIR results is needed for the two epoxies (see Figures 3a, 3b, 4a and 4b).

In this study, Epoxy 1 was randomly selected as the reference FTIR spectrum. Quantities $r \leq 0.83$, as shown in Table 2, for Epoxy 2 are observed for the whole FTIR and fingerprint regions. The quantities r in this study may be correlated to the paint formulation. It is relatively common to set $r \geq 0.95$ as the acceptable tolerance in order to suggest the similarity of different samples. By taking in all the considerations of the random errors derived from the operator performing the analysis, consistency of sample preparation, allowing the paint manufacturers to adjust paint rheology by using solvents etc; quantity $r \geq 0.85$ is proposed as the acceptable tolerance in this case. Epoxy 1 and Epoxy 2 with $r < 0.85$ are suggested to have essential difference in the paint formulation.

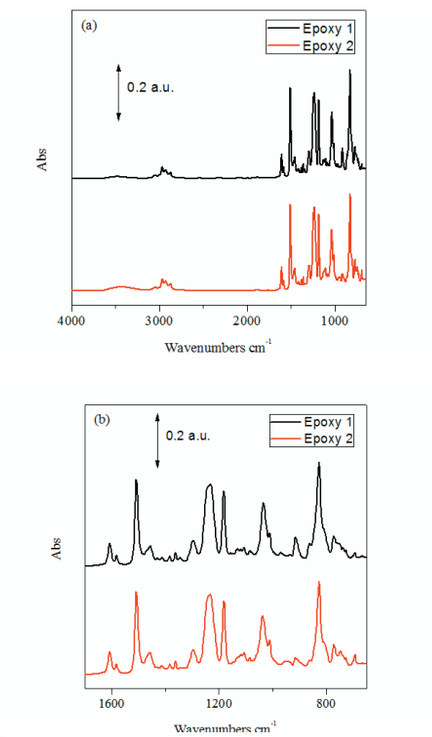


**Figure 3** Spectra of two different epoxy resins for a) whole region b) fingerprint region

**Table 2** Degree of similarity *(r)* for Epoxy 1 and Epoxy 2

| **Sample** | ***r*** **650 - 4000 cm$^{-1}$** | ***r*** **650 - 1700 cm$^{-1}$** |
|---|---|---|
| Epoxy 1 | reference | reference |
| Epoxy 2 | 0.83 | 0.83 |

Hardener 1 was randomly selected as the reference FTIR spectrum. In Table 3, quantities $r \leq 0.03$ are reported for Hardener 2 for the whole FTIR and fingerprint regions. Without any dispute, Hardener 1 and Hardener 2 have essential difference in the paint formulation.

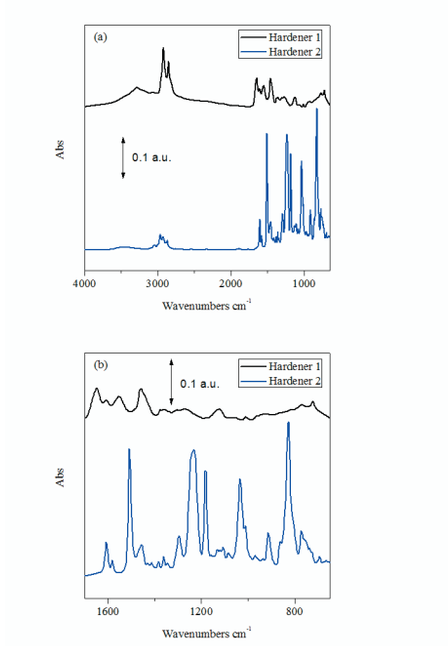


**Figure 4** Spectra of two different hardeners for **a)** whole region **b)** fingerprint region

**Table 3** Degree of similarity *(r)* for Harderner 1 and Harderner 2

| **Sample** | ***r*** **650 - 4000 cm$^{-1}$** | ***r*** **650 - 1700 cm$^{-1}$** |
|---|---|---|
| Hardener 1 | reference | reference |
| Hardener 2 | 0.0004 | 0.003 |

**Conclusion**

Each year, oil & gas companies worldwide spend billions of dollars on polymeric coatings for corrosion protection of steel structures and pipelines for the transportation of crude oil and gas. The frequent failures of the polymeric coatings lead to the corrosion of steel structures and pipelines and thus, leakage of crude oil and gas to the environment. Since mid 90s, oil & gas companies in Malaysia have called for a quality assurance certificate of the supply of polymeric coatings from local paint manufacturers. However, the acceptance of FTIR as one of the tools to fingerprint and to characterize the polymeric coatings is not well received from local paint manufacturers. In this study, FTIR spectrometer was used to analyze single-component systems (the color organic pigment) and multi-component systems (the epoxy paints). The four yellow color organic pigments having similar yellow color as well as the two epoxies and two hardeners having similar physical appeareance were fingerprinted by FTIR. Different chemical structures of the four yellow color organic pigments; and different paint formulations of the two epoxies and two hardeners are unveiled. In conclusion, fingerprinting of polymeric coatings using FTIR spectrometer is possible and reliable.

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# Composite thermal damage – Correlation of short beam shear data with FTIR spectroscopy portable, non-destructive analysis

**Authors**
Alan Rein and John Seelenbinder
Agilent Technologies, Connecticut, USA.
Email:mee-ling_chow@agilent.com

**Abstract**
Agilent is a member of the Center for Composite Materials Industrial Consortium with a different product focus than most other Consortium members. Agilent is in the business of producing portable, handheld non-destructive testing analyzers based on Fourier transform infrared spectroscopy (FTIR). Along with aircraft manufacturers, Agilent has been extensively analyzing advanced composites with this technology.

A specific area Agilent has been asked to explore is degradation processes in composites caused by a variety of external physical and chemical stresses. The following example describes work Agilent has carried out at CCM, correlating the physical effects of thermal exposure to composites with molecular analysis via FTIR.

**Introduction**
The use of medium modulus carbon fiber resin composite in aircraft manufacturing is expanding. There is a corresponding increasing need for non-destructive testing tools that can assess the affect of environmental stresses on composite. Environmental stresses can include moderate to high temperatures, ultraviolet (UV) light, or chemicals such as paint stripper, hydraulic fluid, jet fuel or de-icing solutions. Many of these environmental stresses may weaken the resin component of the composite, reducing the overall strength of the composite before the composite part cracks or de-laminates.

One of the tools that is used for assessing the condition of composite resin is Fourier transform infrared spectroscopy (FTIR). Traditionally, samples are removed and brought to a laboratory for FTIR molecular analysis. At the suggestion of airline manufacturers, Agilent developed the 4100 ExoScan FTIR, a high performance, handheld FTIR spectrometer. The rationale for this approach is to enable the analyzer to be brought directly to the site of the sample, enabling the condition of the composite resin to be assessed non-destructively.

**Analyzing thermal damage in composites by FTIR**
In collaboration with the University of Delaware Center for Composite Materials, the 4100 ExoScan system was used to detect changes in an epoxy carbon composite that result from exposure to thermal stresses. The specific goal was to determine if the handheld FTIR can detect changes in the molecular structure of the composite induced by the increasing exposure temperatures, and then to determine if the spectral changes can be correlated to changes in physical strength of the composite. One of the challenges was to determine if the FTIR system, which analyzes the surface of the composite, can provide information that is indicative of physical affects in the bulk composite.

Cytec 977-3/IM7 epoxy/carbon composite coupons were made by the CCM staff and then were individually exposed for 15 minutes to temperatures ranging from 350 to 550 F. Using the 4100 ExoScan FTIR, spectra of different spots on these coupons were measured at 8 cm-1 resolution; each analysis took approximately 30 seconds. The interlaminar shear strength was measured by a short beam shear (SBS) test on seven replicate samples at each temperature. The infrared (IR) measurements were correlated to the relative strength measured by SBS.

As the exposure temperature increases, increasingly strong carbonyl bands at 1680 and 1720 cm-1 appear, indicating oxidation of the epoxy resin. Additionally, other bands in the fingerprint region indicate degradation of the epoxy backbone.

Epoxy carbon composites decrease in strength due to temperature exposure before disbanding and de-lamination can be observed.

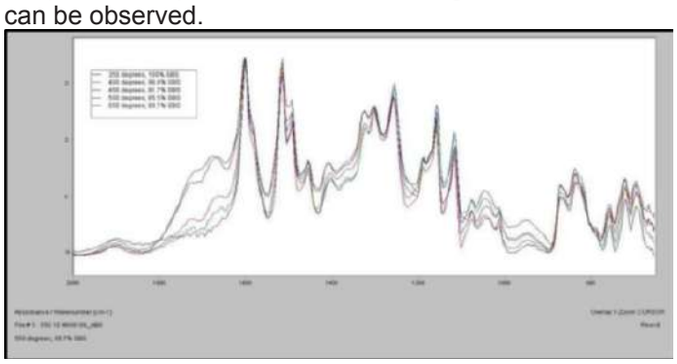

**Figure 1.** Changes that occur in the spectra of 977-3 composite as a function of temperature. The carbon fiber component of the composite strongly scatters the IR light; however, the resin component can still be easily measured.

This decrease can be observed by a decreasing SBS strength with increasing temperatures as is shown in Figure 2. This decrease is due to degradation of the resin, which can be measured by FTIR as shown above. Therefore, a correlation should exist between the FTIR measurement and the SBS strength.

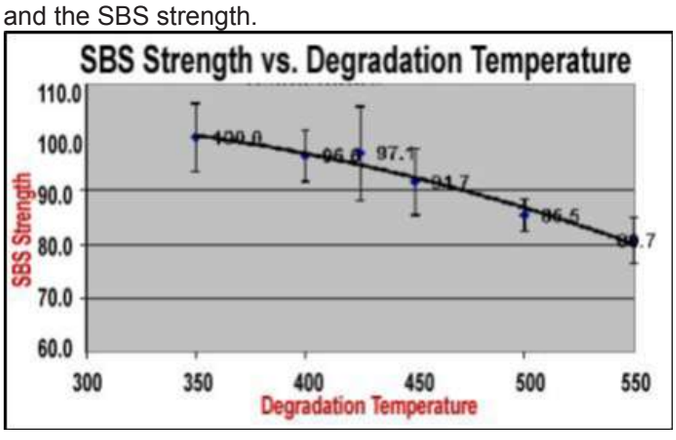


**Figure 2.** Decreasing SBS strength with increasing temperature.

The relationship between the relative SBS strength and the FTIR spectra measured by the 4100 ExoScan was determined using a partial least squares correlation. The data was pre-processed using a Savitsky-Golay first derivative and mean centering. The correlation of actual to predicted values using a cross-validation was 0.95.

Using the above correlation, predictions were made on a separate set of samples. The results of the separate validation set are listed in Table 1. An average error of 1.89% was obtained, which is well within the standard deviation of the short beam shear data itself of 3 to 8%. This shows that FTIR can be used to accurately predict the reduction in strength of an epoxy carbon composite due to high temperature exposure.

**Table 1.** Separate validation set results.

| Temperature (°F) | Actual relative SBS | Predicted SBS | % Error |
|---|---|---|---|
| 350 | 100 | 103 | 3.0 |
| 350 | 100 | 99.9 | 0.1 |
| 400 | 96.6 | 96.8 | 0.2 |
| 400 | 96.6 | 95.4 | 1.2 |
| 450 | 91.7 | 92.8 | 1.1 |
| 450 | 91.7 | 94.3 | 2.6 |
| 500 | 85.5 | 82.3 | 3.2 |
| 500 | 85.5 | 86.3 | 0.8 |
| 550 | 80.7 | 80.6 | 0.1 |
| 550 | 80.7 | 87.3 | 6.6 |
| | | Average error | 1.89% |

## Conclusion and further work

In this brief project, the ability of a handheld FTIR to both detect thermal damage in a composite material and to correlate the damage to the physical change in strength as indicated by SBS measurements is demonstrated. Though the FTIR method is fundamentally a non-destructive surface measurement, in this study the results do effectively correlate to changes in the strength of the bulk composite.

Agilent plans far more extensive work with CCM in the use of the 4100 ExoScan FTIR for detecting damage in composites as well as other projects associated with the importance of understanding surfaces in composites, metals and ceramic materials. In other on-going projects, the 4100 ExoScan system has already provided benefit in detecting surface contamination that can affect bonding and coating processes, as well as in assuring that coatings, primers and paints are of correct thickness, uniformity and physical configuration. Agilent is interested to determine if other CCM Industrial Consortium members have problems or projects, for which this technology could provide.

# ERRATA

The editorial committee regrets an error in Materials Mind issues no 4 article
FT-IR Fingerprinting of Organic Coatings: Possible and Practicialities Industry by Dr. Chew Kong Chin. Table 4 shall read as:

| Sample | Correlation (650-4000 $cm^{-1}$) | Correlation (1690-1780 $cm^{-1}$) |
|---|---|---|
| Epoxy primer (Reference) | 1.00 | 1.00 |
| Epoxy primer with 2% polyester resin | 0.99 | 0.81 |
| Epoxy primer with 5% polyester resin | 0.98 | 0.71 |
| Epoxy primer with 10% polyester resin | 0.95 | 0.63 |

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Fingerprinting III
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# Forum on "Towards Fingerprinting of Polymeric Coatings" III

## Objective

Each year, oil & gas companies worldwide spend multi-million dollars on polymeric coatings for corrosion protection of steel structures and pipelines for the transportation of crude oil and gas. The frequent failures of the polymeric coatings lead to the corrosion of steel structures and pipelines and thus, leakage of crude oil and gas to the environment. These pose a severe inventory loss to the companies and serious threat to the environment, and also cause many safety issues to plant, personnel and surrounding public. Since mid 90s, PETRONAS, Shell Malaysia, Exxon Mobil Malaysia and other oil companies have called for a "mill certification" of the supply of polymeric coatings from local paint manufacturers for the quality assurance of the coatings supplied. However, there was widespread perception within the oil and gas industry that certification of polymeric coatings was not possible because the expertise on spectroscopic analyses and interpretation of results for such purpose was not available back then. Hence, the provision of "birth certificate" for polymeric coatings supplied to the oil and gas companies did not materialize.

The Malaysian oil & gas industry had been focusing on the paint quality control inspection, surface preparation (abrasive blasting) and paint spraying application techniques & skills since 1990 to improve coating performance. Despite efforts to improve quality in these 3 skill sets, coating failures continue to get worse. Thus, the oil & gas industry now realizes that the coating materials can be another factor causing the failures. Since materials testing technology, particularly on non-metallic materials, has improved significantly over the past decade, it is timely for the industry to focus on the testing of the coating materials in the same way as metals are tested and issued with a mill certificate.

Forum on "Towards Fingerprinting of Polymeric Coatings" I held on 22nd March 2013, highlighted the prime concerns of the local paint manufacturers, e.g. the protection of product formula, lack of expertise on spectroscopic analyses and interpretation of results. On the other hand, the users of the oil & gas companies suffer from high cost of repainting the steel structures and pipelines when the coatings fail.

A Task Force on Coatings Fingerprinting was set up under IMM in April 2013 to look into the issues brought out by various parties. The end deliverable of this Task Force is to enhance the overall painting coating quality assurance with the aim of ensuring all protective coatings manufacturers supply products according to specifications.

On 11th October 2013, Forum on "Towards Fingerprinting of Polymeric Coatings" II was held. Presentation of the draft of the Coatings "Birth Certificate" by Chairperson of the Task Force, Ms. Nurul Asni Mohamed from PETRONAS GTS, was attempted. Refining on the Coatings "Birth Certificate" based on the feedbacks during Forum II and periodic meetings of the Task Force will be persistently carried out. The objective of the final Forum on "Towards Fingerprinting of Polymeric Coatings" III is to present the "birth certificate" of polymeric coatings, which will be acceptable to the oil and gas companies. The involvement of IMM through multi-lateral discussions and practical trials using the FTIR equipment jointly with the oil and gas operators, paint manufacturers, materials testing organizations and FTIR instrumental specialists over many months have resulted in a new step towards improved quality of paint supply and paint performance in the oil and gas industry.

- **Date** :
  Friday 20 June 2014
- **Time** :
  2.30 – 6.00 pm
- **Venue** :
  Holiday Inn Hotel
  Glenmarie Shah Alam,
  Selangor
- **Jointly organized by**:
  IMM Polymer Committee
  IMM Coatings Committee
- **Co-sponsors** :
  Research Instruments
  Agilent Technologies

## Qualification for New Maintenance Painting System and Products for Offshore Application

Mr. Muhd Hawari Hassan, PETRONAS GTS Dept

**Abstract**

Corrosive external environment at offshore poses a great deal of challenges for the operators to sustain high integrity and reliability of equipment and piping. Visual inspection reveals that protective coatings failures occur after relatively short span of application. There are many areas for improvement for conventional paint application. This paper highlights the initiative to improve the coating performance through setting up new requirement for testing and qualification prior to site application. Among discussion points are limited surface preparations, simulation of real conditions during applications, testing protocol, challenges and opportunity.

## Biodata

Mr. Mohd. Hawari Hasan has been with PETRONAS for over 17 years. After 10 years in refinery, he transferred to PETRONAS Group Technical Solutions (GTS) and got promoted to Technical Professional position. Under GTS, he serves all PETRONAS OPUs (downstream and upstream sectors, local and abroad) providing technical consultancy especially in Corrosion matters. His responsibilities include PETRONAS Technical Standard Corrosion Discipline Custodian, Development of Corrosion Management Program (CMP), Corrosion Design Basis Memorandum (CDBM) and Asset Integrity Limit (AIL), Pipeline Corrosion Assessment for Process Optimization & Fitness for Service, Corrosion Study for PETRONAS Risk Based Inspection, and Selection and qualification of Protective Coating and Integrity Chemical Injection. He is also the PETRONAS Coating Committee leader.

## FTIR Spectroscopic Method for Laboratory Analysis of Polymeric Coatings.

Ms. Renee Teo Yong Yin, Research Instruments Sdn Bhd

**Abstract**

The Oil & Gas Industry has raised the concerns of polymeric coatings quality and seeks to establish a fingerprinting method to ensure polymeric coatings supplied to the industry can be effectively monitored. The Fourier Transform Infra-Red or FTIR Spectrometer can analyze polymeric coatings to create a base fingerprint which can then be used as a pass-fail reference for daily batch production of polymeric coatings in a paint factory. This presentation will highlight the many trials conducted on various epoxy coatings used in the oil & gas industry. The simplicity of sample analysis by FTIR and interpretation of results with the assistance of FTIR software on epoxy resins and hardeners will be unveiled subsequently. In conclusion, fingerprinting of epoxy resins and hardeners using the FTIR spectrometer in the paint laboratory is possible, reliable and can be accurately reproducible.

## Biodata

Ms. Renee Teo has worked in production sector as a Quality Control and also in commercial lab as a Chemist. She is experienced in handling various analytical instruments such as FTIR, Raman, NIR, ICPMS and UV Spectrophotometer. Currently, she works as an Application Chemist in Research Instruments, and specializes in Thermo Fisher Scientific FTIR, NIR and Raman. She is responsible for installation, application training and troubleshooting.

## Advanced Technology for Polymeric Coatings – What is FTIR Mobile Measurement

Ms. Chow Mee Ling,
Agilent Technologies Sales (M) Sdn Bhd

**Abstract**

Traditionally, polymeric samples are removed and brought to a laboratory for Fourier transform infrared spectroscopy (FTIR) molecular analysis. The rationale for the development of FTIR mobile measurement approach is to enable the analyzer to be brought directly to the site of the polymeric samples, enabling the conditions of the polymeric samples to be assessed non-destructively.

Here, the portable, handheld non-destructive testing analyzers based on FTIR technique as well as some applications on epoxy coatings will be discussed.

## Biodata

Ms. Chow graduated with Master of Philosophy (Chemistry) in University of Malaya. She began her career as QA/QC chemist and later on as laboratory manager at Transformer Oil Analysis Laboratory.

Currently she is the Spectroscopy Product Specialist in Agilent Technologies (Malaysia) Sdn Bhd and delivers technical expertise for molecular and atomic spectroscopy solution implementation to the customer, based on application, method development and technical support.

## Coating Fingerprint Certificate for Every Batch of Paint Manufactured

Ms. Nurul Asni Mohamed,
PETRONAS GTS, Malaysia.

**Abstract**

The Task Force on Coatings Fingerprinting was set up in April 2013 with the ultimate objective to ensure that protective coatings manufacturers supply products according to specifications. Available standards and specifications requiring fingerprinting of polymeric coatings in the Oil & Gas Industry were reviewed. Reliability, reproducibility, short duration of analysis (roughly 1 min) and simple data interpretation of FTIR for fingerprinting of raw materials were concluded. Product formulation, which is of prime concern of the paint manufacturers, will be kept secret. Lastly, the template of the Fingerprint Certificate for every batch of paint manufactured will be presented.

## Biodata

Ms. Nurul Asni Mohamed is the Principal Engineer (Corrosion) with 14 years of experience in PETRONAS Group Technical Solutions. She has an M.Eng. (Materials Science and Engineering) from Imperial College of Science, Technology and Medicine, United Kingdom. She currently works as an Internal Technical Consultant to PETRONAS upstream and downstream business units based in the headquarter office where she is responsible for the in-house CMP software development and deployment to PETRONAS upstream and downstream facilities as well as the CMP documents development for PETRONAS Terengganu Refinery (PPTSB) Condensate Fractionation Unit, Naphtha Hydrotreating Unit and Mercury Removal Unit. Her other responsibilities include Corrosion Management Plan for PETRONAS, Technical Lead for Sea Cooling Water (SCW) System CMP development for Malaysia LNG (MLNG) plant, Root Cause Failure Investigations & Other Consultancy Services.

# Forum on "Towards Fingerprinting of Polymeric Coatings" III

Friday, 20th June 2014
Holiday Inn Hotel Glenmarie
Shah Alam, Selangor

## Programme

1:30 pm : Registration & Tea/Coffee

3:00 pm : Opening Remarks

3.10 pm : Qualification for New Maintenance Painting System and Products for Offshore Application (*Mr. Muhd Hawari Hassan, PETRONAS GTS Dept*)

3:30 pm : FTIR Spectroscopic Method for Laboratory Analysis of Polymeric Coatings (*Ms. Renee Teo Yong Yin, Research Instruments Sdn Bhd*)

3:50 pm : Advanced Technology for Polymeric Coatings – What is FTIR Mobile Measurement (*Ms. Chow Mee Ling, Agilent Technologies Sales (M) Sdn Bhd*)

4:10pm : Tea break

4:25 pm : Demonstration of fingerprinting of epoxy coatings by FTIR (bench top and handheld)

4: 45 pm: Coating Fingerprint Certificate for Every Batch of Paint Manufactured (*Ms. Nurul Asni Mohamed, PETRONAS GTS)*

5:00 pm : Q & A

5:30 pm : Summary & round-up (*Ms. Nurul Asni Mohamed, PETRONAS GTS & Chairperson of IMM Fingerprinting Task Force Committee*)

5:45 pm : Closing Remarks & formalities by Chairperson, IMM Polymer Committee (*Dr. Chan Chin Han, Universiti Teknologi MARA*)

6:00pm : Refreshments & Networking.

7:00pm : Adjourn.

**Prior Registration required**

Free-of-Charge for IMM Members and their Guests
Non-members: RM 40.00
Walk-in Participants: RM 60.00

Institute of Materials, Malaysia
No 10-1, Jalan Bandar 3,
Pusat Bandar Puchong,
47160 Puchong,
Selangor Darul Ehsan, MALAYSIA
Tel: +603-5882 3574
Fax : +603-5882 3524
Website : www.iomm.org.my
Email : admin@iomm.org.my

**Please register with the IMM secretariat at admin@iomm.org.my by 1st June 2014**

# Forum on "Towards Fingerprinting of Polymeric Coatings" III

**Members of the Task Force on Coatings Fingerprinting**

| | |
|---|---|
| Chairperson | Ms. Nurul Asni Mohamed, PETRONAS GTS |
| Deputy chairperson | Ms. Elizah Samat, Sarawak Shell Bhd |
| Advisors | Prof. Dr. Mohamad Kamal Hj. Harun, President, IMM |
| | Ir. Max C. H. Ong, Chairman, IMM Education Committee |
| | Mr. David Lim Chee Cheong, Exxon Mobil E & P, Malaysia |
| | Mr. Zamaluddin Ali, PETRONAS GTS |
| | Pn. Halimah Pit, Shell Deepwater Malaysia |
| | Assoc. Prof. Dr. Chia Chin Hua, Universiti Kebangsaan Malaysia |
| | (Chair of the Forum on "Towards Fingerprinting of Polymeric Coatings") |
| | Assoc. Prof. Dr. Chan Chin Han, Universiti Teknologi MARA, Shah Alam |
| | (Secretary of the Forum on "Towards Fingerprinting of Polymeric Coatings") |
| | Dr. Tan Winie, Universiti Teknologi MARA, Shah Alam |
| | (Committee for Publicity of the Forum on "Towards Fingerprinting of Polymeric Coatings") |
| Secretaries | Ms. Talat Anwar, Assistant Manager, MTE |
| | Mr. M Shahril Atiqi B M Sharip, PETRONAS GTS |
| | Ms. Rohana Jaafar, PETRONAS GTS |
| Committee members | Mr. Abdul Aziz Haron, Head of Paint Testing Laboratory, SIRIM |
| | Mr. Lim Chuan Gee, Senior Researcher, SIRIM |
| | Mr. Kenneth Way, Sales Manager, Perkin Elmer (M) Sdn Bhd |
| | Ms. Jasmine Ooi, Team Leader, Research Instruments (M) Sdn Bhd |
| | Ms. Renee Teo, Application Chemist, Research Instruments (M) Sdn Bhd |
| | Ms. Chow Mee Ling, Spectroscopy Product Specialist, Agilent Technologies Sales |
| | Mr. Frankie Chua Cheng Huat, Director, PLC Laboratory Sdn Bhd |
| | Mr. Terence Wee, Technical Manager, PPG-Sigma Coatings |
| | Mr. Vincent Y. S. Tan, General Manager, Jotun (M) Sdn Bhd |
| | Mr. Wong Ing Chiew (alternate) National Sales Manager, Jotun (M) Sdn Bhd |
| | Mr. Ahmad Badli Shah Aziz, Business Development Manager, International Paints |
| | Mr. Ricky Szeto (alternate), Manager, International Paints |
| | Mr. Lewis Yee (alternate), Engineering Sales Manager, International Paints |
| | Mr. Selvandran, Technical Service Manager, Hempel (M) Sdn Bhd |
| | Mr. Liew Shann Ching (alternate), Deputy General Manager, Hempel (M) Sdn Bhd |
| | Mr. Tan Ying Teck, Kansai Coatings (M) Sdn Bhd |
| | Ms. Lim Suat Ping (alternate), Kansai Coatings (M) Sdn Bhd |
| | Mr. Robert Lo, General Manager for Heavy Duty Coating Division, KCC Paints Sdn Bhd |
| | Mr. Theng Soo Siang (alternate), Technical Manager, KCC Paints Sdn Bhd |
| | Mr. Kirk Keng Chuan, General Manager, MTE |

# Forum on "Towards Fingerprinting of Polymeric Coatings" III Committee members:

| | |
|---|---|
| Chairperson | Dr. Chia Chin Hua, Universiti Kebangsaan Malaysia |
| Secretary | Dr. Chan Chin Han, Universiti Teknologi MARA, Shah Alam |
| Publicity | Dr. Tan Winie, Universiti Teknologi MARA, Shah Alam |
| Member | Mr. Casey Teh King Chong, Director, TenAsia Corporation Sdn. Bhd. |
| | Ir. Yeoh Eng Huei, Manager, Nippon Paints Marketing Co. (M) Sdn. Bhd. |
| | Shamsul Farid Samsudin , PETRONAS Research |
| | Mr. Imizan B A Bakar, Polymer specialist cum Manager at PETRONAS Chemicals Polyethylene Sdn Bhd. |
| | Dr. Chew Khoon Hee, Head of Materials Engineering Division School of Technology Tunku Abdul Rahman College |

# AWF-AWS Welding Activities

**Distinguished Guests:** Dato' Ir. Yeow Kian Chai (Front row: 3rd from the right) and Datuk Ir. (Dr) Abdul Rahim Hashim (4th from right) and Ir. Abdul Aziz Yahya (2nd from right)


**L - R:** Mr. Ang Chee Pheng, Secretary-General, Asian Welding Society and Ir. Dr. Edwin Jong, Chairman, IMM Welding Committee.

Kuala Lumpur 15th November 2013

A Welding Forum on issues pertaining to Technical Integrity Initiatives in Welding; Welding Cost Efficiency Initiatives in Malaysia and Welding Inspection & Quality Issues in Malaysian Industries, Welding Qualification & Certification and Current Practices was held at the Malaysian Petroleum Club at the PETRNOAS Twin Towers. The presenters were Ang Chee Pheng (Secretary-General, AWF), Dr. Edwin Jong (Chairman, IMM Welding Committee), Hafidzuddin Salleh (Secretary, IMM Welding Committee), John Gayler (Managing Director, Certification Department, AWS) and Jeff Hufsey (Advisor AWS).

The various welding issues regarding cost efficiency and current practices on welder qualification and certification in the country call for a corporate system that will address these matters effectively. In introducing the Common Welder Certification Scheme (CWCS) & Manpower Optimization System MOS), AWF hopes to overcome and manage the current insufficiencies.

Dato' Ir. Yeow Kian Chai in his speech on behalf of Datuk Anuar Taib (Vice-President & Chief Executive Officer, PETRONAS Development & Production and President, PETRONAS Carigali Sdn Bhd). Datuk Anuar Taib said "PETRONAS desires improved welder quality and work flow through the AWF Common Welder Certification Scheme and MOS".

IMM is thankful to the Advisor of IMM, Datuk Ir. (Dr) Abdul Rahim Hashim who graced the occasion. Also in attendance was Ir. Abdul Aziz Yahya (Director of Industrial Safety, DOSH).

The forum was organised by IMM and co-sponsored by Malaysian Welding & Joining Society and United Technology (M) Sdn Bhd.

**I am glad to be here:** The AWF & AWS delegates and members of IMM visit Skybridge at the 42nd Floor of the PETRONAS Twin Towers, Kuala Lumpur City Centre.

**L - R:** John Gayler (Managing Director, Certification Department AWS) and Jeff Hufsey (Advisor AWS).

# AWF AWS Collaboration Meeting

Kuala Lumpur 14th November 2013

The Asian Welding Federation (AWF) and the American Welding Society (AWS) held a preliminary discussion on mutual recognition for Welder Qualification Test between AWF Common Welder Certification Scheme and AWS/ ASME.

The meeting was inspired by an article in the WELDPOINT, published on Sept. 2012 by Dr. Zhou Wei of the Singapore Welding Society (SWS). In it, Mr. Walter Sperko, Vice Chairman of ASME Section IX and Chairman of US TAG to ISO/TC44, said that "a welder qualified under ISO 9606-1:2012 is also qualified under ASME Section IX and AWS B2.1".

The AWF delegation was led by Ang Chee Pheng (Secretary-General). Others in the AWF delegation were Dr. Edwin Jong, Leo Paul, Hideaki Harasawa, Shoichi Nomura and Eddie Ko. AWS was represented by John Gayler (Managing Director, Certification Department) and Jeff Hufsey (Advisor).

IMM, MWJS and United Technology played host and treated the delegates to fine Chinese dinner.

# AWF Auditor/Examiner Workshop

Kuala Lumpur 14th November 2013

The Asian Welding Federation (AWF) conducted a workshop to prepare auditors and examiners from Malaysia and other member nations. This is in line with its objective and continuing efforts to set and maintain the quality of welders registered in the Common Welding Certification Scheme (CWCS).

Several local Welding Inspectors and Engineers participated in the session with others from Japan, Singapore and China. They were provided training in the rules for the implementation of the Common Welder Certification Scheme (CWCS) in fusion welding. It included issues on Qualification Test of Welders and Guidelines for auditing management systems based on ISO 19011. The half day workshop also covered conformity assessment with general requirements for bodies operating certification of persons (ISO/IEC 17024) and the general requirements for the competence of testing and calibration laboratories under ISO/IEC 17025.

The exercise was led by Shoichi Nomura from the Japan Welding Engineering Society.

# UTM OGFEST 2013


**IMM & IMTCE2014:** Azman Murad (L) explains IMM, IMTCE2014

Skudai 20th November 2013

The Institute of Materials, Malaysia (IMM) supported the Oil & Gas Festival 2013 organised by the students of the Universiti Teknoloji Malaysia (UTM) within the campus in Skudai. IMM was amongst several companies to have booths in the festival to promote and recruit students and visitors as potential employees

# Visit to Technip Duco Plant


The visting team headed by Pn Halimah Pit (2nd from left) received a warm welcome from the host, Mr G E Lemaire and Mr Aswini (3rd from right and 3rd from left, resp.)

Visit to Asiaflex Products Sdn Bhd
Pasir Gudang, Johor
24 October 2013

A group of IMM members visited flexible pipe manufacturing plant, Asiaflex Products Sdn Bhd in Tanjung Langsat industrial estate, Pasir Gudang, Johor. Technip (the plant equity holder) has 2 other similar plants operating in France and Brazil; the plant in Johor is the newest of the three. The 1st shipment of the flexible pipes was made in Sept 2011 for subsea Sepat oil development in Terengganu.

# Half-Day Paint Workshop


Bintulu, 2nd November 2013

61 participants from 6 local contractors attended a Half Day Paint Workshop jointly organized by IMM Bintulu Chapter and PPG Performance Coatings (M) Sdn Bhd.
The subjects on Overview of Corrosion & Corrosion Protection, Coating Defects and Surface Preparation, Mixing of Paint and Paint Application were expounded during the workshop.
The participants were very positive and enthusiastic about the workshop. Many expressed interest in attending similar events in future. Mr. Yii Ming Sing, IMM Bintulu Chapter Chairman, stated “future sessions would involve the sharing of knowledge and experiences by local Coating Inspectors.”

# Professor Saifollah’s Professorial Lecture


**Prof. Dr. Saifollah Abdullah with well wishers** (L to R): Prof. Dr. Sabu Thomas (Mahatma Gandhi University), Assoc. Prof. Dr. Melissa Chan Chin Han (UiTM), Ir. Max Ong (IMM Hon. Secretary), Prof. Dr. Che Husna Azhari (UKM), Ir. Suradi Yasin (IMM Hon. Treasurer).

Shah Alam, 23rd October 2013

Congratulations to our IMM Council Member and Chairman of the Green Materials Committee !!!

Professor Saifollah Abdullah of Universiti Teknologi MARA (UiTM) gave a professorial lecture titled “Nanotechnology: The Disruptive Technology”, which was held at UiTM Shah Alam. He defined Nanotechnology as a “manipulation of matter on an atomic or molecular scale”, and described it as a new wave of technology which may replace all current technology by the year 2015, hence its reputation as a “disruptive” force in the world of Materials Science. The main focus of Professor Saifollah’s research is on the topic of Nanotechnology. Most of his work has been published in internationally refereed and Scopus-indexed journals. He has also contributed numerous articles to the mainstream media in the field of Nanotechnology, in order to spread awareness about the topic.

# Introduction to Metals for Medical Devices

by Hendra Hermawan

*Hendra Hermawan is a member of IMM. He received his PhD in Materials Engineering from Laval University, Canada in 2009. He did a postdoc with a Barcelona-based medical devices manufacturer for two years before joining the Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia. His research interests include metals for biomedical applications and corrosion engineering. He is a registered CEng with the Engineering Council UK and a member of IOM3. He holds a CP-2 certificate from NACE International. He serves as Adjunct Professor at the Department of Mining, Metallurgical and Materials Engineering, Laval University. He also serves as an Editorial Board Member of Journal of Orthopaedic Translation (Elsevier). To contact the author, please visit his website: http://fbme.utm.my/hendra*

## 1. Introduction

In January 2012, the Parliament of Malaysia has passed the Law of Malaysia Act 737 known as the Malaysian Medical Device Act (MDA) 2012. The MDA 2012 regulates the registration of medical device and conformity assessment body, license and permit, and enforcement. One of the most important aspects of medical devices is biomaterials, the materials of which the devices are made. In Malaysia, research on biomaterials has been growing rapidly. For the last 3 years there are more than thousand of publications as recorded in Scopus, the most referred scientific database, with the leading institutions including Universiti Teknologi Malaysia (UTM), Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM), International Islamic University of Malaysia (IIUM) and Advanced Materials Research (AMREC) SIRIM.

In line with the MDA 2012 enactment, this article aims to introduce metals, as the most used biomaterials for medical devices. Metals for medical devices have experienced vast devel-opment and clinical uses since the invention of stainless steel in 1920s. It was then fostered by the formation of ASTM Committee F04 on Medical and Surgical Materials and Devices in 1962 that played an important role for the practice and standardization. A great variety of corrosion resistant metals have been developed and used for medical devices (especially implants) including the class of 316L stainless steels, cobalt-chromium (Co-Cr) alloys and ti-tanium (Ti) and its alloys. New generation of alloys has been made nickel (Ni) free via novel processing including nano-processing and amorphization. Other development exploited the concept of biodegradable rather than inert metals where temporary medical implants, that function only during specific period and then degrade, were targeted. This article is mostly taken from the author's book entitled "Biodegradable Metals: From Concept to Applications" with permission from the publisher, Springer.

## 2. Metal Implants

Metals were chosen for use in the intervention of trauma, disease or malfunction of organs where loading present. In the early development, insufficient strength and corrosion were two main problems faced by metal implants [1]. The introduction of corrosion resistant 18-8 stainless steel solved most of corrosion problem and thereafter stimulated the vast develop-ment and clinical use of metal implants. Nowadays, hundreds of type of metals for implants has been used. In general they can be grouped into: 1) stainless steel alloys; 2) Co-Cr alloys; 3) Ti and its alloys; and 4) precious alloys. Figure 1 shows some examples of medical implants where metals are used.

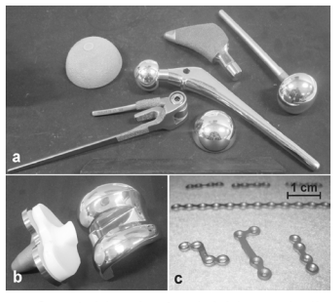


Fig. 1 Examples of metal implants: (a) hip and elbow implants, (b) knee arthroplasty, (c) craniofacial plates. Courtesy of MediTeg, Universiti Teknologi Malaysia

Metals are used by considering their two key features: the structural function and the inert-ness. However in the current development, it is desirable that an implant also possesses bi-oactivities or biofunctionalities such as blood compatibility and bone conductivity. Therefore surface modifications are employed. For example, metals have been coated with hydroxy-apatite to provide bone conductivity [2], or with biopolymers to improve blood compatibility [3]. Development on metallic biomaterials includes those composed of nontoxic and allergy-free elements [4] and biodegradable metals targeted for use as temporary implants [5].

## 3. Requirements for Metal Implants

In clinical practice, metal implants are subjected to the conditions as described in Table 1. First of all, they are used in contact with living tissues thus they need to be biocompatible. Other functional characteristics that are important include adequate mechanical properties such as strength, stiffness, and fatigue properties; and also appropriate density.

| Condition | Parameters | Consequences |
|---|---|---|
| Body temperature | 37°C | Chemical reaction works faster than in ambient temperature |
| pH [6]:<br>• Blood<br>• Intercellular matrix<br>• Cells | 7.15 - 7.35<br>7.0<br>6.8 | Even though body fluids are buffered solutions, pH temporary can de-crease to ~5.2 around implantation site [7]. |
| Dissolved oxygen [8]:<br>• Arterial blood<br>• Venous blood<br>• Intercellular matrix | 100 mmHg<br>40 mmHg<br>2 ~ 40 mmHg | Corrosive environment |
| Chloride ion [6]:<br>• Serum<br>• Interstitial fluid | 113 mEq/l<br>117 mEq/l | Corrosive environment |
| Mechanical load [9]:<br>• Cancellous bone<br>• Cortical bone<br>• Arterial wall<br>• Myocardium<br>• Muscle (max)<br>• Tendon (max) | 0 - 4 MPa<br>0 ~ 40 MPa<br>0.2 - 1 MPa<br>0 - 0.02 MPa<br>40 MPa<br>400 MPa | Could lead to fracture, stress corrosion cracking |
| Load repetition [9]:<br>• Myocardial contraction<br>• Finger joint exercise<br>• Ambulation | $5 \times 10^6$ - $4 \times 10^7$ /year<br>$10^5$ - $10^6$ /year<br>$2 \times 10^6$ /year | Could lead to fatigue, wear and fretting |

Table 1 Body environments to which metal implants are subjected

Metal implants are also required to be non-magnetic and have high density in order to be compatible with magnetic resonance imaging (MRI) techniques and to be visible under X-ray imaging, respectively. Most of artificial implants are subjected to loads, either static or repeti-tive, and this condition requires an excellent combination of strength and ductility. This is the superiority of metals over other materials such as polymers and ceramics.

In addition, specific requirements of metals depend on the specific implant applications. Stents and stent grafts are implanted to open stenotic (narrowed) blood vessels; therefore, they require plasticity for expansion and rigidity for maintaining dilatation. In orthopaedic im-plant applications, metals are required to have excellent toughness, elasticity, rigidity, strength and resistance to fracture. Additionally, for total joint replacement metals are needed to be wear resistance to avoid debris formation from friction. Dental restoration requires strong and rigid metals and even the shape memory effect for better clinical outcomes.

## 4. Metallic Biomaterials

The selection of metal used in biomedical depends on the specific implant applications. The 316L type stainless steel (SS316L) is still the most widely used alloys in all implant division ranging from orthopaedic to dentistry. However, when an implant requires high wear re-sistance such as an artificial joint, Co-Cr alloy would better serve. Table 2 summarized type of metals generally used for different implants division.

| Division | Implants | Type of metal |
|---|---|---|
| Ortho-paedic | • Bone fixation (plate, screw, pin)<br>• Spinal fixation<br>• Artificial joints | SS316L; Ti; Ti-6Al-4V<br>SS316L; Ti; Ti-6Al-4V; Ti-6Al-7Nb<br>Co-Cr-Mo; T-6Al-4V; Ti-6Al-7Nb |
| Craniofacial | Plate and screw | SS316L; Co-Cr-Mo; Ti; Ti-6Al-4V |
| Cardiovascular | • Artificial valve<br>• Stent<br>• Pace maker case<br>• Stent graft | Ti-6Al-4V<br>SS316L; Co-Cr-Mo; Ti<br>Ti; Ti-6Al-4V<br>SS316L |
| Otorhinology | • Artificial eardrum<br>• Artificial inner ear (elec-trode) | SS316L<br>Pt |
| Dentistry | • Filling<br>• Inlay, crown, bridge<br>• Orthodontic wire<br>• Dental implant | Ag-Sn(-Cu) amal-gam, Au<br>Au-Cu-Ag; Au-Cu-Ag-Pt-Pd; Ti; Co-Cr<br>SS316L; Co-Cr-Mo; Ti-Ni; Ti-Mo<br>Ti; Ti-6Al-4V; Ti-6Al-7Nb; Au |

Table 2 Implants division and type of metals used

Chemical composition is one of the basic characteristics of metals which determine the formed microstructure and phases, thus their properties, i.e. mechanical properties. For ex-ample, the addition of Aluminum (Al) and Vanadium (V) into pure Ti greatly increase its ten-sile strength. Beside composition, metallurgical state of the metals changes their mechanical properties, i.e. annealed condition has better ductility than that of cold worked. The process to synthesis metals also affects their microstructure and properties. As an example, cast metal implants usually possess lower strength than those made by forging.

### 4.1. Stainless steels

Till now, the three most used metals for implants are stainless steel, Co-Cr alloys and Ti al-loys. The first stainless steel used for implants contained ~18wt% Chromium (Cr) and ~8wt% Ni made it more resistant to corrosion and stronger than steel. The addition of Molybdenum (Mo) further improves its corrosion resistance, known as type 316 stainless steel. Further advancement was the reduction of its Carbon (C) content from 0.08 to 0.03wt% that im-proves corrosion resistance to Chloride (Cl)-containing solution, and named as 316L. The ASTM has standardized stainless steel for surgical implants in their F138 [10], F899 [11] and F2181 [12] standards.

### 4.2. Co-Cr alloys

These alloys are generally known for their excellent wear resistance where they have been in use in dentistry for many decades and in making artificial joints. Wrought Co-Ni-Cr-Mo alloy, for example, has been used for making loaded joints such as the hip and knee arthroplasty. ASTM standards covered these alloys include F75 [13], F90 [14], F562 [15], F1537 [16].

### 4.3. Ti and Ti alloys

Having density only 4.5 g/cm3, Ti is featured by its light weight compared to 7.9 g/cm3 for 316 stainless steel and 8.3 g/cm3 for cast Co-Cr-Mo alloys [17]. The most known Ti

alloys, Ti-6Al-4V, are considered as having excellent tensile strength and pitting corrosion resistance. When alloyed with Ni, Ti-Ni alloy or better known as Nitinol, possesses a shape memory effect which is an attractive property used for example in dental restoration wiring. Titanium and its alloys for medical applications were covered in ASTM standards F67 [18], F136 [19] and F2063 [20].

### 4.4. Precious alloys

Precious metals and alloys such as Gold (Au), Silver (Ag), Platinum (Pt) and their alloys are mostly known in dentistry due to their good castability, ductility and resistance to corrosion. Included into dental alloys are Au-Ag-Copper (Cu) system, Au-Ag-Cu with the addition of Zinc (Zn) and Tin (Sn) known as dental solder, and Au-Pt-Palladium (Pd) system used for porcelain-fused-to-metal for teeth repairs [21].

### 4.5. Other metal and alloys

Tantalum (Ta), amorphous alloys and biodegradable metals are among other metals used for implants. Due to its excellent X-ray visibility and low magnetic susceptibility, Ta is often used for X-ray markers for stents. Interesting properties have been shown by amorphous alloys compared to its crystalline counterparts whereas they exhibit a higher corrosion resistance, wear resistance, tensile strength and fatigue strength. Amorphous alloys like that of Zirconium (Zr)-based [22] with its low Young's modulus may miniaturized metal implants. Amorphous Magnesium (Mg)-based alloys have also shown a favorable degradation behav-ior where hydrogen evolution was not observed [23].

## 5. Non-metallic Biomaterials

Biomaterial is defined as a nonviable material used in a medical device which is intended to interact with biological systems [24]. Biomaterials are used to make devices to replace a part or a function of the body in a reliable, safe, physiologically acceptable and economic manner [25]. It covers a broad range of materials from metals, ceramics and polymers, to compo-sites. Table 3 summarizes materials commonly used as biomaterials.

| Materials | Advantages | Disadvantages | Applications |
|---|---|---|---|
| Metals: stainless steel, Ti alloys, Co-Cr alloys, Mg alloys, etc. | Though, strong, ductile | Non bioactive | Load bearing implants; dental implants, joint replacement, cardiovascular stents, etc. |
| Ceramics: zirconia, alumina, bioglass, calcium phosphate, etc. | Bioactive, inert, | Brittle, not resilient | Orthopaedic and dental implants |
| Polymers: nylon, polylactide, polyethylene, polyesters, etc. | Bioactive, resilient | Not strong | Blood vessel grafts, sutures, hip sockets, etc |
| Composites: amalgam, fiber-reinforced bone cement, etc. | Tailor made | Relatively difficult to make | Bone cement, dental resin |

Table 3 Materials commonly used for biomedical applications

### 5.1. Ceramics

Ceramics biomaterials (bioceramics) can be divided into: 1) inert bioceramics: zirconia, alu-mina, aluminum nitrides and carbon; 2) bioactive ceramics: hydroxyapatite, bioglass, etc.; 3) biodegradable/resorbable ceramics: calcium aluminates, calcium phosphates, etc. The inert-ness, high compressive strength and good appearance make ceramics attractive for dental crowns. Carbon has been used for heart valves exploiting its high specific strength and blood compatibility. Many bioceramics have been also applied as coating onto metal surfaces including nitrides, diamond like, carbon and more recently bioglasses and hydroxyapatites. A book written by Kokubo can be consulted for further reference on bioceramics [26].

### 5.2. Polymers

The main advantage of polymeric biomaterials over metals and ceramics is the ease of manufacturability to produce various shapes. Polymeric biomaterials can be divided into: 1) non-absorbable such as poly(methyl methacrylate), polyamide or nylon, poly(ethylene), etc.; and 2) absorbable such as poly(glycolide acid) and poly(lactide acid), etc. They can be a bulk (solid or gel) or coating onto metal surfaces with tailored mechanical and physical properties. In recent development, absorbable polymers have been used for drug delivery carriers loaded with a specific drug in the form of coating on for example drug eluting stents. Jenkins has published a book which can be referred for further details on biomedical polymers [27].

### 5.3. Composite

Bone is an example of composite biomaterials. It is a composite of the low elastic modulus organic matrix reinforced with the high elastic modulus mineral "fibers" permeated with pores filled with liquids. Composites allow a control over material properties whereas a combination of stiff, strong, resilient but lightweight can be achieved all together. Other examples of biomedical composites include: orthopaedic implants with porous structures, dental filler, and bone cement composed of reinforced poly(methyl methacrylate) and ultra-high-molecular-weight poly(ethylene). Further reading on biomedical composites can be found in a book au-thored by Ambrosio [28].

## 6. Recent Development

### 6.1. Nickel-free alloys

Elimination of all possibility of toxic effects from leaching, wear and corrosion has become a great concern. Stainless steels have been further developed to be Ni-free by replacing Ni with other alloying elements while maintaining the stability of austenitic phase, corrosion re-sistance, magnetism and workability. This has lead to the use of Nitrogen (N) creating Fe-Cr-N, Fe-Cr-Mo-N and Fe-Cr-Mn-Mo-N systems [4]. The achieved higher strength opens the possibility for reduction of implant sizes where limited anatomical space is often an issue, for example, coronary stents with finer meshes [4].

### 6.2. Low elastic modulus alloys

In the recent development metallic biomaterials are desired to exhibit low elastic modulus, increased wear resistance and workability. Elastic moduli of Ti-Niobium (Nb) systems such as Ti-29Nb-13Ta-4.6Zr [29] and Ti-35Nb-4Sn [30]

can go down to 50-60 GPa which are closer to that of cortical bone (10-30 GPa). Wear resistance of cast Co-Cr alloy has been improved by maximizing C content and addition of Zr and N where optimal precipitation hardening permits the formation of fine and distributed carbides and the suppression of σ-phase [31]. Improved workability of wrought Co-Cr alloys has been achieved by adding N to suppress carbides and intermetallics [32].

### 6.3. Porous metals

Apart from dense metallic biomaterials, porous structured metals offer further reduction on elastic modulus to get closer to that of cortical bone. This structure can be fabricated through powder sintering, space holder methods, decomposition of foaming agents and rapid proto-typing [33]. A combination of rapid prototyping with investment casting [34], or powder sinter-ing [35], or 3D fiber deposition [36] and or selective laser melting [37] are some of promising process for the development of porous metal structure for biomedical implants. Solid free form fabrication, a mouldless manufacturing techniques or rapid prototyping, have been suc-cessfully used to fabricate complex scaffolds. These technologies allow the preparation of tissue-engineered constructs with a controlled spatial distribution of cells and growth factors, also controlled gradients of scaffold materials with a targeted microstructure [38].

### 6.4. Metallic glasses

A novel class of metals, metallic glasses, currently attracts attention from biomaterialist [39]. Nickel-free Zr-based bulk metallic glasses represent their interesting properties where tensile strength, low elastic modulus and corrosion resistance are superior to those of crystalline al-loys [40]. These metals have high resistance to crystallization during cooling that allow the formation of bulk amorphous alloys or bulk metallic glasses [41]. These alloys exhibit unusual combinations of engineering properties such as very high specific strength, and elastic strain limit which some are interesting for biomedical use.

### 6.5. Biodegradable metals

With recent development in biotechnology, new concept of bioactive biomaterials, rather than inert biomaterials, was raised. A positive interaction of implant with the physiological site is promoted. Some level of biological activity is needed in particular area, such as in tissue engineering, where direct interactions between biomaterials and tissue components are very essential. In particular cases, biomaterials are needed only temporary and are expected to support the healing process and to degrade thereafter. These degradable biomaterials may be defined as materials used for medical implants which allow the implants to degrade in human body environment [5]. Biodegradable/bioabsorbable polymers were the first inves-tigated for use as biomaterials [42]. Meanwhile, the idea of considering biodegradable metals to fabricate temporary implants required in some sort breaking the paradigm where corrosion resistance has always constituted one of the main requirements for metallic biomaterials.

## 7. Regulation on Biomaterials

Finally, to be used clinically a biomaterial must be approved by authoritative bodies such as the United States Food and Drug Administration (FDA) or European conformity (CE) mark-ing. With the FDA, the proposed biomaterial will be either granted Premarket Approval (PMA) if substantially similar to one used before the 1976 FDA legislation, or has to go through a series of guided biocompatibility assessments. In Malaysia, with the enactment of the MDA 2012, all medical devices must be approved by the Medical Devices Authority, Ministry of Health Malaysia.

## 8. Conclusion

In some applications, ceramics and polymers have been replaced metals owing to their ex-cellent biocompatibility and biofunctionality. However, those require high strength, toughness and durability, are still made of metals. With additional biofunctionalities and revolutionary use of metal such as for biodegradable implants, metals will continue to be used as biomaterials in the future. The direction goes toward the combination of the mechanically superior metals and the excellent biocompatibility and biofunctionality of ceramics and polymers to obtain the most desirable clinical performance of the implants.

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# UTM Corrosion Talk

**Holding court**: Ir. Max Ong speaking on Corrosion

**Welcome**: Assoc. Prof. Dr. Izman Sudin

Skudai 20th November 2013

Ir. Max Ong, Honorary Secretary of IMM, provided students and participants a captivating talk on Corrosion Control in Oil & Gas Industry – Academia Collaboration Considerations at Universiti Teknoloji Malaysia.

Ir. Max Ong (P.Eng., C.Eng., C. Env., Int.P.E., APEC Eng.) and IMM & NACE Corrosion Specialist started the discussion by introducing the interaction of the corrosive environment in the upstream of the oil and gas industry. He highlighted that "there are four methods of corrosion control, mainly cathodic protection, coatings, corrosion inhibitors and materials selection."

In an interactive session with the audience, Max challenged them to provide simple to manufacture, simple to install, simple to apply, quick to complete work, low defects and lower failure rate solutions to the oil and gas industry.
Assoc. Prof. Dr. Izman Sudin, Head of Department, Faculty of Engineering, UTM played host to the event.

# IMM Corrosion Technician Certification Course

**Watch & learn:** Practical Training on Retrieval Tool

The Institute of Materials, Malaysia (IMM) organised 2 sessions of the IMM Corrosion Technician Certification Course (Level 1). A total of 36 technicians went through the paces of the course in Labuan and Miri.

Whilst participants in Labuan underwent a straight 4-day session, those in Miri enjoyed the convenience of attending over 2 weekends to accommodate participants' schedule. It was an opportunity for more candidates to take the course.

The Corrosion Technician Course covers theoretical and practical training. After the training, learners will be acquainted with the Fundamentals of Corrosion (Electrochemistry & Forms of Corrosion), Engineering Materials, Corrosion Control by Design, Cathodic Protection, Corrosion Inhibition, Protective Coatings & Lining, Corrosion Monitoring, Handling of Retrieval Tools and Service Valves, Cathodic Protection Survey and UT Thickness Gauging.

For enquiries on the course, please contact Materials Technology Education Sdn Bhd at info@mte.com.my or call (03) 5882 3574

**Teamwork:** Corrosion Technician Course participants learning together

# NOU signing - Politeknik Kuching


Group photo with YB Datuk Patinggi Tan Sri (Dr.) Alfred Jabu Numpang (centre), Deputy Chief Minister of Sarawak. From left Datu Dr Haji Julaihi Hj Bujang (left), Government & External Liaison, Swinburne University of Technology Sarawak, Madam Clara Ong Guat Leng, Director Politeknik Kuching Sarawak, Tn. Hj. Kamaruddin Bin Hamzah, Deputy Director General of Jabatan Pengajian Politeknik and Mr. Andrew Ronggie , IMM Kuching Chapter Advisor.

Kuching, 4 Oct 2013 – Signing on Note of Understanding (NOU) ceremony between Politeknik Kuching Sarawak and Institute of Materials Malaysia. NOU is on setting up IMM Student Chapter at Politeknik Kuching Sarawak. The contents of NOU such as Joint conferences, training courses, seminars and activities of similar nature; Exchange of academic material and other information; Activities of mutual interest such as dissemination of activities; Linkage websites of both parties; and any other areas of collaboration as may be mutually agreed upon by both parties.

Politeknik Kuching Sarawak was represented by Madam Clara Ong Guat Leng and IMM was represented with Mr. Andrew Ronggie, IMM Kuching Chapter Advisor.


En. Nuzul Azwan Bin Sulaiman (second from left), IMM Kuching Chapter Chairman representing IMM to donate to Rumah Seri Kenangan Kuching in conjunction with Politeknik Kuching Sarawak Silver Jubilee Celebration. Also the picture, Madam Clara Ong Guat Leng (fourth from left), Politeknik Kuching Sarawak and Datuk Hj. Mohlis Bin Jaafar (fifth from left), Director General, Jabatan Pengajian Politeknik.


Mr. Andrew Ronggie (far right), IMM Kuching Chapter Advisor exchanged the Note of Understanding (NOU) with Madam Clara Ong Guat Leng, Director Politeknik Kuching Sarawak. It was witnessed by YB Datuk Patinggi Tan Sri (Dr.) Alfred Jabu Numpang, Deputy Chief Minister of Sarawak (white shirt) and Tn. Hj. Kamaruddin Bin Hamzah, Deputy Director General of Jabatan Pengajian Politeknik. Also signing NOU with Politeknik Kuching, Datu Dr Haji Julaihi Hj Bujang (left), Government & External Liaison, Swinburne University of Technology Sarawak.

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Ellia bt Ab Rahim
ellia@mte.com.my

Tel: 03-58823574
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# IMM Course Schedule 2014

| Course/Training | Duration (Days) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **COATINGS COURSES** | | | | | | | | | | | | | |
| Protective Coatings Technician Certification Scheme | 1 | weekly | weekly | weekly | weekly | weekly | weekly | weekly | weekly | weekly | weekly | weekly | weekly |
| Blasting & Painting Supervisor | 2 | 9-10 | | 27-28 | | 22-23 | | | 21-22 | | 2-3 | | 18-19 |
| Coatings Quality Control Technician (QC) | 2 | | | 10-11 | | | 10-11 | | | 22-23 | | | 2-3 |
| Coatings Inspection Certification Scheme Level 1 | 4 | | 18-21 | | 8-11 | | 24-27 | | | 22-25 | | 25-28 | |
| Diploma of Applied Science (Coatings Technology) | 10 | | 24-28 | | | | | 14-18 | | | | | |
| Corrosion Control by Protective Paint | 2 | | 18-19 | | 21-22 | | 24-25 | | | 8-9 | | 25-26 | |
| Thermal Spray Coatings Applicator | 2 | | | | 3-4 | | | | | | 30-31 | | |
| Thermal Spray Coatings Inspector Level 3 | 4 | | 24-27 | | | | | | | 22-25 | | | |
| | | | | | | | | | | | | | |
| **WELDING COURSES** | | | | | | | | | | | | | |
| IMM Welding Inspection Scheme | 5 | | | 17-21 | | 5-9 | | | | | 13-17 | | 8-12 |
| Associate Welding Engineer (JWES) * | 6 | Please call (03) 5882 3574 or email info@mte.com.my for updates | | | | | | | | | | | |
| Welding Engineer (JWES) * | 6 | | | | | | | | | | | | |
| Senior Welding Engineer (JWES) * | 6 | | | | | | | | | | | | |
| Calculation of Strength of Welded Members | 1 | | | | 7 | | | 14 | | | 5 | | |
| Cost & Estimation of Welding Projects | 1 | | | | 8 | | | 15 | | | 6 | | |
| Interpretation of Weld Quality by Welding Codes | 1 | | | | 9 | | | 16 | | | 7 | | |
| Interpretation of Weld Quality by Radiographic Metho | 1 | | | | 10 | | | 17 | | | 8 | | |
| | | | | | | | | | | | | | |
| **CORROSION COURSES** | | | | | | | | | | | | | |
| Corrosion Control By Cathodic Protection | 2 | | | 17-18 | | | | | 11-12 | | | | 8-9 |
| Cathodic Protection Technologist | 4 | | | 17-20 | | | | | 11-14 | | | | 8-11 |
| Corrosion Technician | 4 | | 25-28 | | | 20-23 | | | | 9-12 | | 11-14 | |
| | | | | | | | | | | | | | |
| **OTHERS COURSES** | | | | | | | | | | | | | |
| Vibration Specialists (Level 1,2,3,4) | | Please call (03) 5882 3574 or email info@mte.com.my for updates | | | | | | | | | | | |
| Blasting & Painting Training Course | 5 | | | | | | | | | | | | |
| Welding – SMAW, GMAW, GTAW (1G - 6G) | 5 | | | | | | | | | | | | |
| API-570 Piping Inspector | 5 | | | | | | | | | | | | |
| API-510 Pressure Vessel Inspector | 5 | | | | | | | | | | | | |
| API-653 Above Storage Tank Inspector | 5 | | | | | | | | | | | | |
| Microbiologically Influnced Corrsoion | 2 | | | | | | | | | | | | |
| Management of MIC | 1 | | | | | | | | | | | | |
| Welding and Joining technology for Non Welding Pers | 1 | | | | | | | | | | | | |

Registration and full payment of course must be made at least 2 months prior to the course

Registration to be made through MOS (www.primos.com.my)

*Fees : Inclusive PRIMOS registration, IMM membership, where applicable

Venue: Kuala Lumpur- subject to change with or without prior notice

Upon Request-Protective Coatings Technicians certification Scheme

Organizer :

Disclaimer: All dates are subject to change without notice. Please contact Materials Technology Education SdnBhd at (603) 5882 3574 or email info@mte.com.my for the latest schedule and information.

## ABOUT IMM

Institute of Materials, Malaysia (IMM) is a non-profit professional society that promotes honourable practice, professional ethics and encourages education in materials science, technology and engineering. Engineers, academicians, technicians, skilled workers and professionals are amongst its members exceeding 4000.

Registered with the Registrar of Societies on 6th November 1987, the Malaysian Materials Science & Technology Society (MMS) changed its name to the Institute of Materials, Malaysia (IMM) on 16th June 1997. The objectives of the IMM include the training and development of individuals and companies in Malaysia to attain professional recognition in various fields of materials science, technology and engineering.

IMM is administered by a council of 30 members, with volunteers leading 12 materials committee, and 7 regional chapters, and supported by a secretariat with full time staff.

Membership of IMM is categorised into 7 different grades and open to anyone above the age of 17 years - individuals and companies keen in developing and contributing towards the growth of materials science, technology and engineering in Malaysia.

Over the years, IMM have conducted courses on coatings, corrosion and welding in support of the oil and gas industry in Malaysia. Over 600 Coating Inspectors have been trained and certified as well as 2,500 Blasters & Painters, supervisors and Corrosion technicians. Its certification programmes are recognized by PETRONAS and all oil & gas operators. Since January 2011, 42 Associate Welding Engineers, 33 Welding Engineers and 8 Senior Welding Engineers were trained and certified.

IMM has also organised 8 International Materials Technology conferences (IMTCE) on a biennial basis, and numerous technical seminars, educational programmes, technical visits, and materials awareness programmes since 1988.

Public courses, such as Microbiologically Influenced Corrosion (MIC) and Welding Technology for Non-Welding Personnel, are been offered occasionally. Training on materials awareness has also been conducted in public listed companies.

The courses and programmes are being organised by Materials Technology Education Sdn Bhd (MTE), a joint-venture between IMM and InterMerger Group.

Collaborations with the Asian Welding Federation, American corrosion society SSPC, Sabah Skills Technology Centre (SSTC), and local universities continue to be part of IMM's vision and long term mission to educate, train and serve the materials fraternity


***CONTACT INFORMATION***

*Institute of Materials, Malaysia*
*No. 10-1, Jalan Bandar 3*
*Pusat Bandar Puchong*
*47160 Puchong Selangor*

*Email : iomm@po.jaring.my*
*Website: www.iomm.org.my*
*Tel. 03-5882 3574*
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## IMM MEMBERSHIP GRADES

*Honorary Fellow (Hon. FIMM) - Fellow (FIMM)*
*Professional Member (MIMM) - Associate Member (AMIMM)*
*Company Member - Ordinary Member - Student Member*
** Details and forms are available in IMM website*
** Term and condition apply for each grade of membership*

| Category / Fee | A | B | C | D |
|---|---|---|---|---|
| *Honorary Fellow* | *EXEMPTED* | | | |
| *Fellow ( F.I.M.M )* | - | *RM300.00* | *RM10.00* | *RM150.00* |
| *Professional Member ( M.I.M.M )* | - | *RM150.00* | *RM10.00* | *RM100.00* |
| *Company Member (CO)* | *RM 50.00* | - | - | *RM200.00* |
| *Associate Member ( A.M.I.M.M)* | - | *RM150.00* | *RM10.00* | *RM80.00* |
| *Ordinary Member* | *RM20.00* | - | - | *RM40.00* |
| *Student Member* | *RM10.00* | - | - | *RM10.00* |
| *Affiliate Ordinary Member* | *RM40.00* | | *EXEMPTED* | |
| *NB: Members above the age of 55 years shall pay 50% of the fees* | | | | |

*Note: (A) Entrance (B) Processing (C) Transfer (D) Annual Subscription*
*For membership details, contact the Secretariat at:*
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# Materials & Asset Integrity Seminar

## in conjunction with 24th IMM Annual General Meeting

**Friday 21st March 2014**

**2.30 PM**

**Dewan Presiden,**

**Kelab Golf Negara Subang, Kelana Jaya**

IMM members and guests :
FREE OF CHARGE (Prior registration required)
Non Members: RM 40.00
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Registration by email to admin@iomm.org.my
Before 10 March 2014

**PROGRAMME**

2.30 PM – REGISTRATION & TEA/COFFEE

3.15 PM – OPENING REMARKS

*MOHAMAD AZMI MOHD NOOR (CHAIRMAN, IMM MATERIALS & ASSET INTEGRITY COMMITTEE)*

3.30 PM – MATERIALS QUALITY IN ACHIEVING ASSET INTEGRITY

*MAIMUNAH ISMAIL (IMM)*

3.50 PM – CRITICAL ASPECTS OF MATERIALS TESTING AND CODES REQUIREMENT

*NOR FAZRI NORDIN (SR ASSET INTEGRITY ENGR, LLOYD'S REGISTER)*

4.10 PM – TEA BREAK

4.30 PM – MATERIALS & MANUFACTURING PROCESSES

*ROSNANI RASADI (SR ENGINEER, MATERIALS ENGINEERING PETRONAS CARIGALI SDN BHD)*

4.50 PM – CORROSIVE MIX / INJECTION POINTS-SHELLS EXPERIENCES IN MITIGATION

*ZAMIR MOHAMED DAUD (SHELL)*

5.10 PM – Q & A AND CLOSING REMARKS

5.30 PM – TEA BREAK

6.00 PM – IMM AGM

7.00 PM – ADJOURN

**IMM Materials & Asset Integrity Committee**

| | | |
|---|---|---|
| Chairman: | Ir. Mohamad Azmi Mohd Noor | (PETRONAS) |
| Members: | Dato' Ir. Jai Suboh | (Velosi) |
| | Ir. Maimunah Ismail | (IMM) |
| | Mohamad Azwin Osman | (Newfield) |
| | Rosnani bt. Rasadi | (PETRONAS) |
| | Zamir Mohamed Daud | (Shell) |


Institute of Materials, Malaysia

10-1 Jalan Bandar 3
Pusat Bandar Puchong
47160 Puchong
Tel: (03) 5882 3574
Email: admin@iomm.org.my
Website: www.iomm.org.my