IMIDAZOLE CORE AMINE/EPOXY AND RHA SILICA BASED COMPOSITES COATINGS FOR CORROSION RESISTANT APPLICATION

G. Jayabharathi[1], S. Jothiramalingam[1], A. Hariharan[2], M. Alagar[2]

[1]*PG & Research Department of Chemistry, A.V.V.M. Sri Pushpam College (Affiliated to Bharathidasan University), Poondi, Thanjavur Dt., Tamil Nadu, India*
[2]*Polymer Engineering Laboratory, PSG Institute of Technology and Applied Research, Coimbatore, Tamil Nadu, India*
*Corresponding author: bharathi.sarju@gmail.com

ABSTRACT

Imidazole core monoamine (IMA) was synthesised and used as a hardener for epoxy resin. The epoxy resin was reinforced with varying weight percentages of 3-glycidoxypropyltrimethoxysilane (GPTMS) functionalized rice husk ash bio-silica to obtain respective composites. Their composite morphology was studied using SEM analysis. The cure behaviour of imidazole core diamine hardener and DGEBA epoxy resin was studied. The thermal stability of the corresponding epoxy matrix and bio-silica reinforced epoxy composites were studied by thermogravimetric analysis (TGA). The values of limiting oxygen index calculated from TGA data infer that all the samples of epoxy matrix and composites possess good flame retardant behaviour. In order to ascertain their hydrophobic behaviour, the water-contact angle measurement studies were carried out. The values of contact angle obtained for neat IMA/DGEBA matrix is 84°, where as that of 1, 3, 5, 7 and 10wt% bio-silica reinforced IMA/DGEBA are 87°, 90°, 93°, 95° and 98° respectively. IMA/DGEBA matrix and functionalised bio-silica reinforced IMA/DGEBA composites were coated on the mild steel specimens and their corrosion resisting behaviour was studied by electrochemical impedance spectroscopy and potentiodynamic polarisation. Data resulted from corrosion studies (Nyquist plot and Tafel plot) inferred that among the coated specimens studied, the specimen coated with 7 wt% bio-silica reinforced IMA/DGEBA matrix exhibits the highest corrosion resisting efficiency due to its water repellent character and morphology.

Keywords: Imidazole amine, Epoxy resin, Bio-silica, Contact angle, Corrosion resistance.

1. INTRODUCTION

Corrosion is a spontaneous and irreversible reaction between a metal surface and its environment, resulting in significant economical losses, the failure of critical components and environmental problems. The prevention of corrosion is one of the main challenges industrially worldwide. The application of protective coatings such as paints or resins, or those based on ceramic materials, is the most common way to improve the durability of metallic alloys significantly. However, organic coatings are relatively thick and can suffer poor thermal and mechanical stability and also a lack of adhesion, while coatings based solely on ceramic materials are likely to be porous and suffer from intrinsic stress-induced cracking, leading to thickness limitations [1-2]. Therefore, organic-inorganic hybrids have been developed to overcome the limitations of traditional coatings, forming an efficient and durable corrosion protection system for metallic surfaces. Among the large number of reported organic-inorganic nanocomposite systems, in which polymers such as epoxy, polyimide, acrylic and polyethylenimine phases are combined with inorganic oxides such as silica, alumina, zirconia, titania and ceria [3] Recently, Chafiq et al. synthesised and investigated the benzimidazole based inhibitors for carbon steel and reported that these inhibitors are effective (93%) at 333 K [4]. These inhibitors contain several sulfur, nitrogen and benzoyl rings, which make inhibitors to be good adsorbent. Chauhan et al. synthesised new bio-macromolecule inhibitors based on triazole-modified chitosan, reported that this inhibitor is environmenta friendly and maximally protect (91.34% at 250 mg/L) steel materials from aggressive acidic corrosion [5]. Berdimurodov et al. created a new imidazoline-based anti-corrosion inhibitor TTHIIDT ((3ar,6ar)-3a,6a-di-p-

tolyltetrahydroimidazo[4,5-d]imidazole-2,5(1 h,3h)-dithione), which is effective at low concentrations in a 1 M hydrochloride acid solution [6]. The prime objective of the present work is to develop bio-silica reinforced epoxy composite coatings to utilize them for protection of mild steel surfaces from corrosion. In this context, imidazole core monomine (IMA) synthesized and was reinforced with varying weight percentages of functionalized bio-silica to obtain composite coatings. These coatings were coated on mild steel and their corrosion protection efficiency was studied by electrochemical method. Data obtained from different studies are discussed and reported.

2. MATERIAL AND METHODS

2.1. Material

Benzil, 4-nitrobenzaldehyde, ammonium acetate, hydrazine monohydrate, 10% palladium on activated carbon, were purchased from Sigma Aldrich, Bangalore, India. Hexane, ethyl acetate and acetic acid were received from qualigens Mumbai, India and DGEBA were purchased from Huntsman Corporation India.

2.2. Synthesis of 4-(4,5-diphenyl-1H-imIMAzol-2-yl)benzenamine (IMA)

The synthesis of 4-(4,5-diphenyl-1H-imIMAzol-2-yl) benzenamine (IMA) (imidazole core monoamine-IMA) involves two steps as shown in Scheme 1. Initially nitro

substituted imidazole (IMN) compound was synthesised in a 250 mL, two-necked, round-bottomed flask equipped with a reflux condenser, benzil (0.05 mol), 4-nitrobenzaldehyde (0.05 mol) and ammonium acetate (0.01 mol) in 25 mL of acetic acid were mixed and heated at 120°C. The progress of the reaction was monitored by thin-layer chromatography (TLC) in 7:3 ratio of hexane and ethyl acetate as eluting solvent. After completion of the reaction, the reaction mixture was cooled to room temperature by continuous stirring for overnight. Then the product was filtered, washed with water and recrystallized from ethanol and collected 2-(4-nitrophenyl)-4, 5-diphenyl-1H-imidazole yellow solid product. Further, nitro compound reduced to amine compound in a 250 mL two-necked flask equipped with a dropping funnel and a reflux condenser, (0.05 mol) of nitro compound and 250 mg of 10% palladium on activated carbon (10% Pd/C,) were dispersed in 100 mL of ethanol. The suspension was heated to reflux, and 10 mL of hydrazine monohydrate was added slowly to the mixture. After 5 h of reflux, THF was added to the mixture and filtered hot to remove Pd/C, and the filtrate was cooled to obtain orange precipitate. The product was collected by filtration, recrystallized with ethanol and dried in vacuum at 80°C. The yielded amino compound was used as a hardener for epoxy resin.
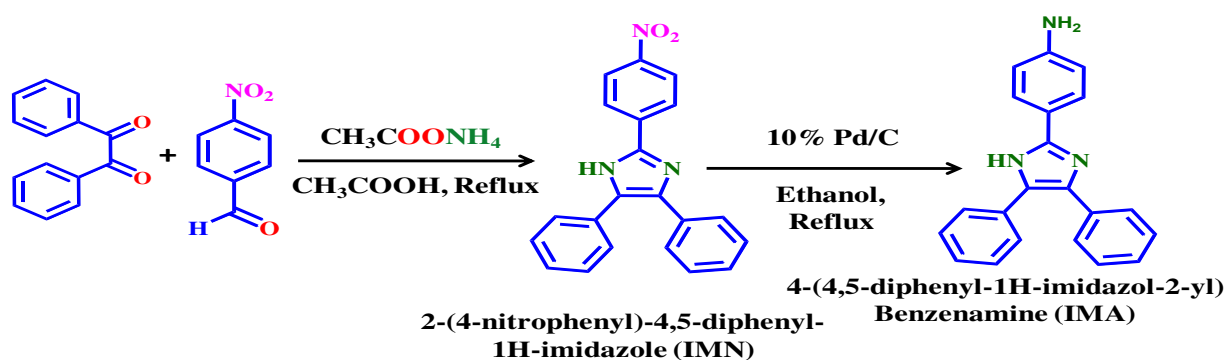
Scheme 1: Synthesis of 44-(4,5-diphenyl-1H-imIMAzol-2-yl)benzenamine (IMA)

2.3. Preparation of silane functionalization on bio-silica

The lignin from rice husk is first removed by the acid treatment, which is one of the most useful routes to remove the wax and oils covering the wall of the surface of natural fibers (Scheme 2). Dried rice husk obtained was bleached with conc. HCl to remove the unwanted contaminants and subsequently washed with

water continuously till the pH became neutral. Then, the product was dried at 60°C for 4 h and calcinated at 600°C for 5 h in a muffle furnace, to obtain rice husk ash in which silica (SiO_2) is the major component (85 %) [7-9].

The prepared rice husk ash (biosilica) was then functionalized with (3-glycidyloxypropyl) trimethoxysilane (GPTMS) in order to reinforce with epoxy matrix.

About 4 ml of GPTMS was stirred with 95% absolute ethanol and 5% deionized water and the resulting solution was sonicated for 15 min (Scheme 3). The pH of the solution was initially adjusted to 4.5 using acetic acid and subsequently sonicated for 1 h in order to ensure the complete hydrolysis of silane. Then 10 g of bio-silica was added, and the resulting mixture was sonicated for 2 h and then refluxed for 24 h at 80°C and centrifuged with the addition of water followed by ethanol and hexane and filtered. The functionalized bio-silica obtained was further dried in hot air oven at 100°C in order to remove the moisture.


Scheme 2: Preparation of rice husk ash bio-silica

2.4. Preparation of neat DGEBA/IMA matrices

Different weight percentages of silane functionalized bio-silica was added into the DGEBA/IMA and subjected to agitation. Then the resulted homogenous mixture was transferred into respective silane coated glass plates and maintained the temperature at 120°C for about 3 h. The obtained light brown coloured thin composite films were characterized.

2.5. Preparation of bio-silica reinforced DGEBA /IMA composites coated MS plate

1, 3, 5, 7 and 10wt% of silane functionalized bio-silica incorporated DGEBA+IMA was coated on MS plate and subjected to curing process. Then the resulted homogenous blend was transferred into respective silane coated glass plates and left to evaporate slowly at 100°C for 3h. Subsequently post cured at 120°C for 3h each until the formation of the light brown coloured thin composites film (Scheme 3).
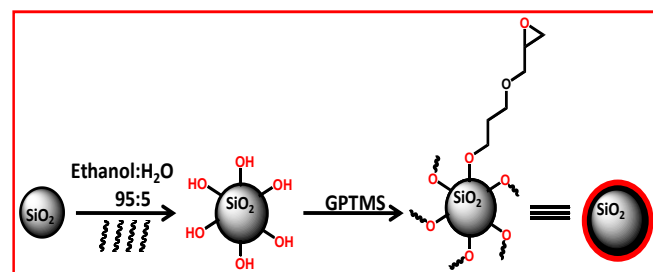
**Scheme 3: Preparation of GPTMS functionalization on bio-silica**
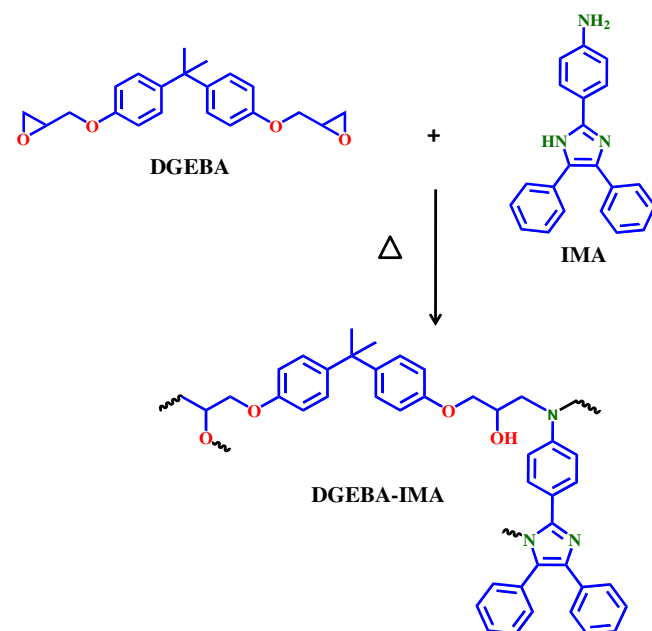
Scheme 4: Synthesis of DGEBA/IMA polymer matrix

2.6. Characterization

FTIR spectra measurements were carried out with Agilent Cary 630 FTIR Spectrometer. NMR spectra were obtained with Bruker (400 MHz) using dimethylsulfoxide (d6-DMSO) as a solvent and tetramethylsilane (TMS) as an internal standard. Thermogravimetric analysis (TGA) was carried out from room temperature to 850°C using NETZSCH STA 449F3 with 5 mg of sample under N_2 flow (60

mLmin-1) at heating rate of 20°C min^{-1}. The morphology of the blended matrices and composites were analyzed from an FEI QUANTA 200F high-resolution scanning electron microscope (HRSEM). Contact angle measurements were obtained using a Kwoya goniometer with 5µl of water as probe liquid. The epoxy metrices coated mild steel plates were tested for their corrosion protection behavior on mild steel in 3.5% sodium chloride solution. The corrosion experiments on mild steel specimens were carried out using open-circuit potential (OCP), electrochemical impedance spectroscopy (EIS) and potentiodynamic polarisation.
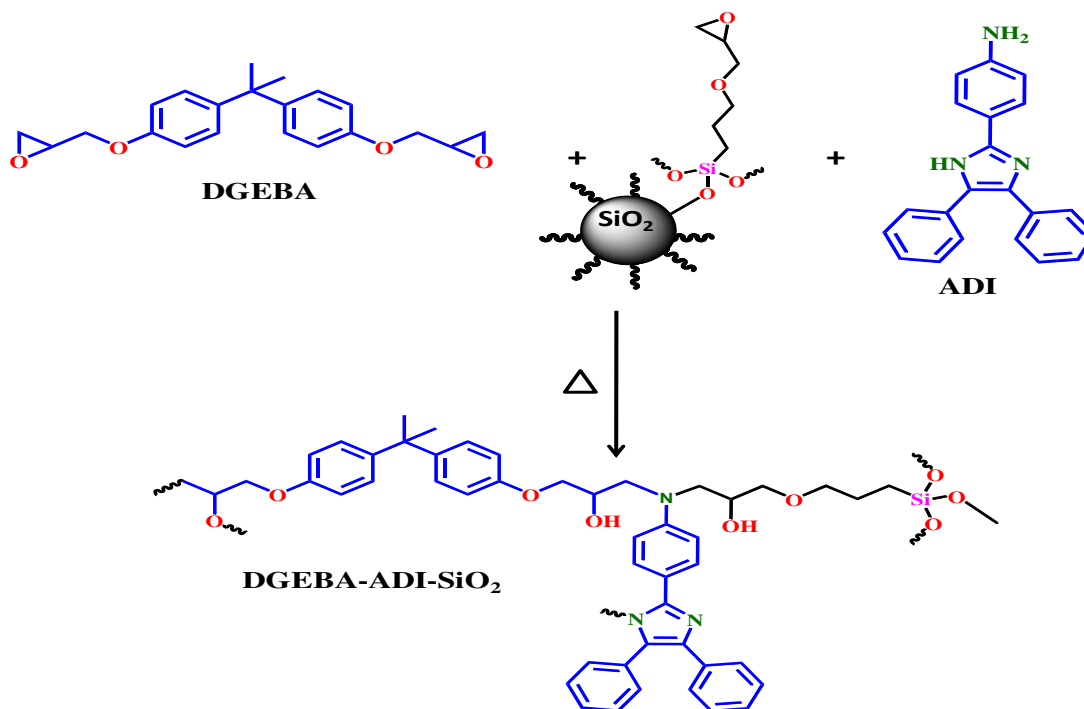
Scheme 5: Preparation of bio-silica reinforced DGEBA/IMA composites

3. RESULTS AND DISCUSSION

3.1. IR spectral analysis

FTIR spectra of bio-SiO$_2$ reinforced epoxy composites are presented in Fig. 1. The absence of peak at 958 cm^{-1} in bio-silica reinforced DGEBA/IMA composites confirms the formation of composites. The absorption peak appeared at 837 cm^{-1} indicates the presence of aromatic substitutions rings. The appearance of peak at 1605 cm^{-1} corresponds to the -N=C- group, which confirms the imidazole core. The peak appeared at 3382 cm^{-1} corresponds to the -OH stretching in the composites. Further, surface bio-silica possesses an active epoxy functional group that takes part in the ring-opening reaction with both DGEBA and IMA. This was confirmed from the existence of peak at 1115 cm^{-1}, that is, Si-O-Si linkage of silica. This confirms that the formation of silica network between epoxy resin and caprolactam is through the oxirane ring present on the surface of silica (Fig. 1).

3.2. IR spectral analysis

TGA thermograms for neat and bio-silica reinforced DGEBA/IMA matrices are shown in Fig.2. The thermal stability of neat and 1, 3, 5, 7 and 10 wt% bio-silica reinforced DGEBA/IMA were studied using the TGA at the heating rate of 20°C min^{-1} under nitrogen atmosphere. The data obtained are presented in table 1 and fig. 2. From the TGA data, it is inferred that an increasing weight percentage of bio-silica reinforced DGEBA/IMA composites systems contributes higher thermal stability to the resulted composites via the strong covalent bonding that occurred between the epoxy and bio-silica reinforcements. The maximum degradation of neat and 1, 3, 5, 7 and 10 wt% bio-silica reinforced DGEBA/IMA composites are noticed at 409, 412, 412, 413, 414 and 435°C, respectively. The char yield of neat and 1, 3, 5, 7 and 10 wt% bio-silica reinforced DGEBA/IMA composites obtained at 16, 17, 19, 22 and 25% respectively.
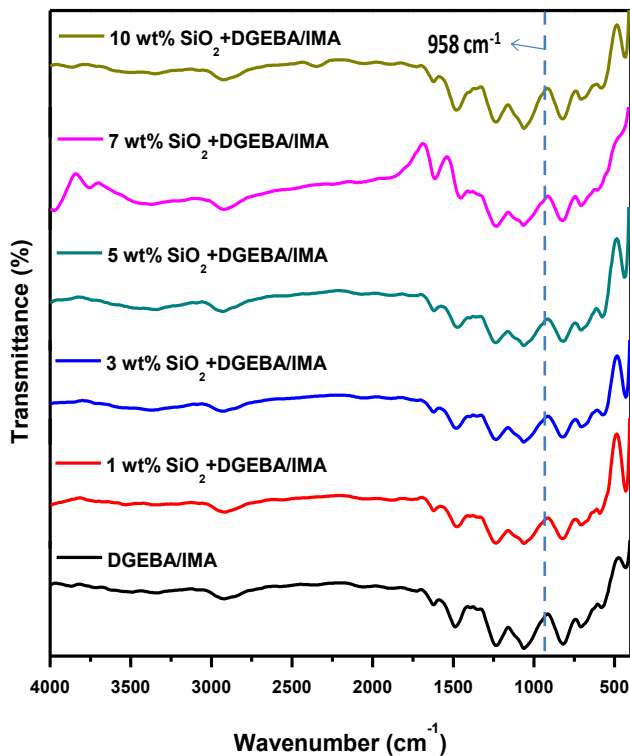
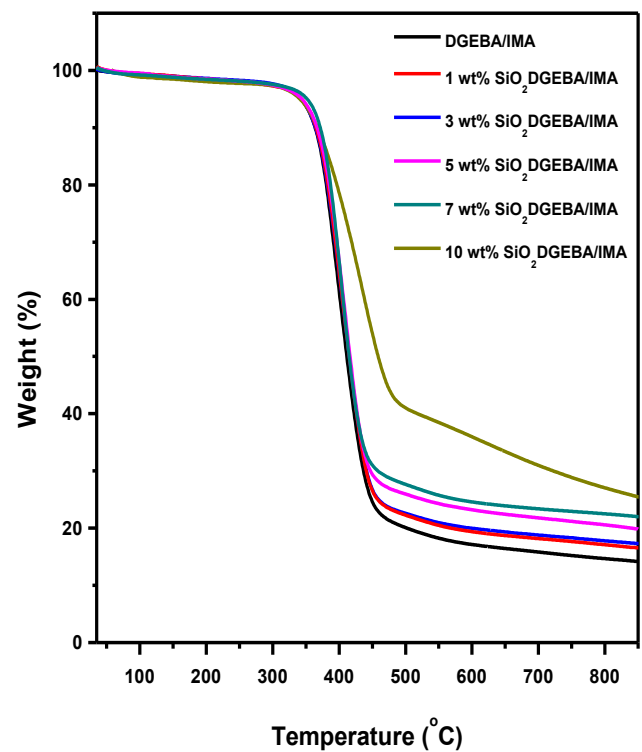**Fig. 1: IR spectra of neat and bio-silica reinforced DGEBA/IMA matrices**

Fig. 2: TGA thermogram of neat and bio-silica reinforced DGEBA+IMA matrices

Table 1: Thermal stability of neat and bio-silica reinforced DGEBA+IMA composites

Sample name	10 % weight loss (°C)	Maximum degradation temperature (°C)	Char yield percentage at 850°C	LOI
Neat DGEBA/IMA	362	409	14	23
1 Wt% SiO$_2$ + DGEBA/IMA	364	412	16	24
3 Wt% SiO$_2$ + DGEBA/IMA	365	412	17	24
5 Wt% SiO$_2$ + DGEBA/IMA	366	413	19	25
7 Wt% SiO$_2$ + DGEBA/IMA	368	414	22	26
10 Wt% SiO$_2$ + DGEBA/IMA	371	435	25	28

3.3. Flame Retardant behavior

The flame retardant behavior of the polymer materials can be predicted from the value of Limiting Oxygen Index (LOI) calculated using char yield obtained from thermo-gravimetric analysis. The value of LOI is calculated using the Van Krevelen and Hoftyzer relation. LOI = 17.5 + 0.4 CR. The percentage char yield (CR) of the sample was obtained from TGA analysis at 850°C (Tables 1). It is experimentally proven that the materials having higher LOI values are flame retardant in nature. Generally, polymers with LOI values greater than 26 are ranked as excellent flame retardant material.

The LOI values of neat and 1, 3, 5, 7 and 10 wt % bio-silica reinforced DGEBA+IMA composites are 23, 24, 24, 25, 26, and 28, respectively. It was also noticed that the value of LOI increases with increase in silica content. The 10 wt% bio-silica reinforced composites shows the LOI value of 28, which is comparatively higher than that of neat matrix and other hybrid composites.

3.4. Microstructural behavior

In order to ascertain the microstructural behavior of the neat and bio-silica reinforced DGEBA-IMA composites, the scanning electron microscopic (SEM) as well as transmission electron microscopic (TEM) analysis were performed. Scanning electron microscopy (SEM) images of both neat and bio-silica incorporated DGEBA-IMA composites are presented in fig. 3. Neat matrix, 1, 3,

5, 7 and 10 wt% bio-silica reinforced DGEBA-IMA composite materials were taken for SEM analysis. It was observed from the images that the bio-silica reinforced DGEBA-IMA matrices exhibit a homogenous morphology without any voids in the matrix systems and thus possesses improved surface properties. The bio-silica reinforcement provides an effective formation of covalent bonding as well as inter cross linking network with epoxy matrix systems, which in turn develops the smooth surfaces and enhanced hydrophobic behaviour.

Furthermore, in order to ascertain the distribution of bio-silica in the DGEBA-IMA matrix, the HR TEM analysis was carried out and the images obtained are presented in Fig. 4. 1 wt %, 5 wt % and 10 wt % of bio-silica reinforced DGEBA-IMA were taken as representative samples for TEM analysis. The TEM images of 1 wt % (Fig. 4a), 5 wt % (Fig. 4b) and 10 wt % (Fig. 4c) bio-silica reinforced nanocomposites show uniform dispersion of silica in the DGEBA-IMA matrices. The distributions of bio-silica ($F\text{-}SiO_2$) are observed to be homogenous even at higher weight percentages. Further, it is interesting to note that the 10 wt % bio-silica/DGEBA-IMA exhibit microspore morphology. This phenomenon influences and contributes to the elevation of high thermal stability and enhanced water contact angle properties achieved with homogeneity of bio-silica. Among the hybrid composites studied, the 10 wt % DGEBA-IMA nanocomposites can be considered as better material for high performance microelectronics applications.
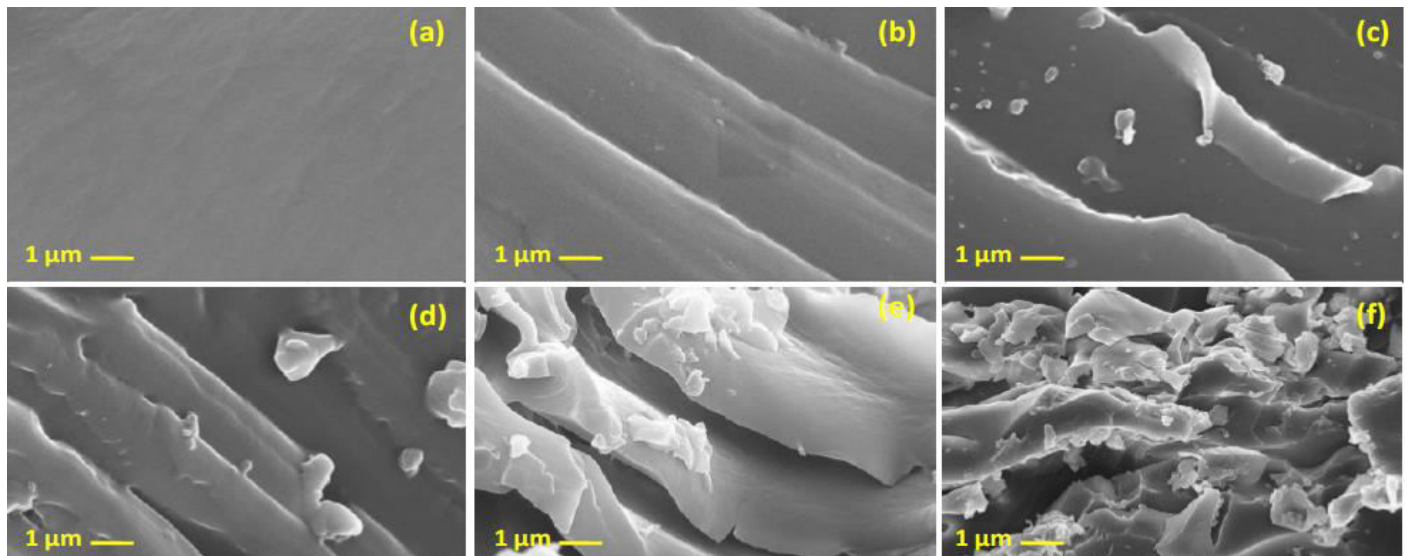

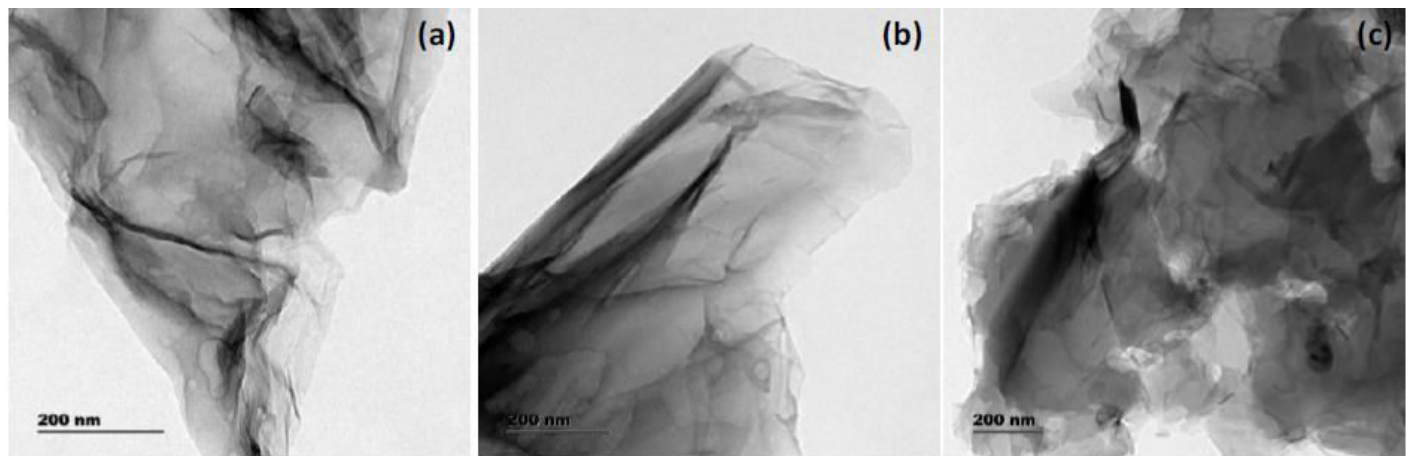**Fig. 3: SEM image of neat and bio-silica reinforced DGEBA–IMA matrices**

Fig. 4: TEM image of (a) 1, (b) 5 and (c) 10 wt% bio-silica reinforced DGEBA–IMA matrices

3.5. Water contact angle studies

It is essential that the material should not be affected, when exposed to moisture environment. It is reported that when the MS are left unpowered under humid environments, the dust and moisture from the air will be deposited on the surfaces and this causes malfunctioning of the electronic devices by short-circuiting. Hence, the materials considered for electronic insulation applications should have inherent water repellency with lower surface free energy. In this context, the water contact angle properties of the developed materials were studied. The contact angle images obtained for neat, 1, 3, 5, 7 and 10 wt % F-SiO$_2$ reinforced DGEBA-IMA composites are given in table 1. It can be observed that the reinforced composites possess the higher values of contact angle when compared to that of neat DGEBA-IMA matrix. The value of contact angle of neat DGEBA-IMA matrix is 84°. Similarly, the values of water contact angle obtained for 1, 3, 5, 7 and 10 wt% of bio-silica reinforced DGEBA-IMA composites are 87°, 90°, 93°, 95° and 98° respectively. The values of contact angle tend to increase with increasing the concentration of F-SiO$_2$ in the composites. Thus, the 10 wt% F-SiO$_2$ reinforced bio-silica reinforced epoxy matrix show the highest values of contact angle of about 98°, respectively. In addition, the presence of intra-molecular hydrogen bonding exist in the epoxy system

also contributes to an enhanced values of water contact angle due to decrease in the surface free energy. It is further reiterated that the bio-silica reinforced epoxy composites with combination of higher values of water contact angle can be considered for high performance corrosion resistant applications under humid environments.

3.6. Corrosion Studies
3.6.1. Preparation of the coatings
Sufficient numbers of uniform size mild steel plates having the size 2 cm x 1 cm were purchased from the local market. The mild steel plates were first thoroughly polished using emery papers. Then these plates were placed on the horizontal table. The required of coating was dropped on the mild steel plate and it was dried in the room temperature for 5h then it was cured in the air oven at 120°C for 3 h.

3.6.2. Corrosion studies using EIS measurements
Electrochemical impedance spectroscopy was used to find out the corrosion resistant property of the bio-silica reinforced DGEBA-IMA composites coating on the mild steel. An impedance analysis was performed using mild steel plate having 2 cm^2 area. The specimens after coating were immersed in 3.5% NaCl solution for different time periods.

Table 2: Corrosion parameters of the coated and bare mild steel specimens in 3.5 % NaCl solution calculated from potentiodynamic polarisation studies

Samples	R$_s$ (Ω cm^2)	CPE$_c$ (F.s^{n-1})	n	R$_c$ (kΩ cm^2)	CPE$_{dl}$ (F.s^{n-1})	n	R$_{ct}$ / kΩ cm^2
Bare MS	7.20	09.11 x e^{-6}	0.878	2.29	2.23 x e^{-2}	0.343	26
Neat DGEBF/IMA	4.029	21.62e-6	0.713	2.332	1.027e-3	0.658	92.05
1 wt% SiO$_2$ DGEBF/IMA	6.509	0.152e-6	0.512	1.617	2.974e-3	0.610	129
3 wt% SiO$_2$ DGEBF/IMA	10.74	75.02e-6	0.722	33.18	1.449e-3	0.723	168.5
5 wt% SiO$_2$ DGEBF/IMA	8.608	8.759e-6	0.523	1.302	3.521e-3	0.712	222.1
7 wt% SiO$_2$ DGEBF/IMA	6.002	9.384e-6	0.606	6.979	1.698e-3	0.756	273
10 wt% SiO$_2$ DGEBF/IMA	30.7	0.182 9e-6	0.305	30.49	1.304e-3	0.835	880

EIS was used to evaluate the barrier properties of the bio-silica reinforced DGEBA-IMA composites films and the effect of silica reinforcement on the corrosion resistance. Nyquist plots derived from the EIS measurements for the coated and uncoated mild steel specimens in 3.5% NaCl solution are shown in Fig. 5. Nyquist plots have only one capacitive semicircle for all the specimens represent the presence of only one time

constant [21]. Hence, fitting of all EIS data is done using simple equivalent circuit model (Fig. 6).
The equivalent circuit was used to evaluate the corrosion resistance data, where Rs is the solution resistance, Rct is the charge transfer resistance and Qc is the double layer capacitance.
Superimposition of the experimental data has been done using this equivalent circuit and corrosion parameters

were obtained. R_s is the resistance of the solution between the working electrode and the counter electrode. Rs values are not only depending on the ionic conductivity of the solution but also depending on the geometrical area of the electrode. Rs values are insignificant data while studying the corrosion property of the film because it does not yield any information about the coating. R_{ct} values are used to measure the resistance of the electron transfer across the metal-solution interface, which is inversely proportional to the corrosion rate of the metal. The calculated values of the corrosion parameters from EIS measurements are given in Table 2. R_{ct} values of the bio-silica reinforced DGEBA-IMA composites coated specimens are higher than that of the bare MS. In order to improve the corrosion resistance behavior of DGEBA-IMA matrix, the varying weight percentage of bio-silica were reinforced in the bio-silica reinforced DGEBA-IMA composites. When the content of bio-silica are increased from 1wt% to 10 wt%, into the bio-silica reinforced DGEBA-IMA composites, the increase in R_{ct} and decrease in double layer capacitance values were observed. It infers an improvement of corrosion resistance behavior which arises from the reduction of pores/cavities present in the polymer coating which could be occupied by the bio-silica [10-12]. The roughness' factor values (n) are continuously decreasing while increasing weight percentage of bio-silica into the polymer matrix which also corroborates the reduction of pores/cavities on the mild steel surface.

Generally, all the organic coatings are not completely impenetrable for long time, their barrier properties could decrease when immersion time increases because of the water/corrosion medium penetration into the coatings. For bare MS, the corrosion medium had a direct contact with the metal surface which led to the generation of many electroactive sites and corrosion will take place freely. Actually, corrosion reaction will takes place in the presence of moisture and oxygen. Silica containing polymer coatings prevent the diffusion of oxygen and aggressive medium into the polymer matrix due to the high crosslinking of polymer network and -Si-O-Si- linking in the polymer network. From the contact angle measurement, it can also be understood that, all the silica containing polymers are hydrobhobic, which could effectively reduce the wettability of polymer which ultimately reduces the sorption of water molecules in the coatings [13]. Among the different wt% of bio-silica reinforced DGEBA-IMA composites

used in the present work, bio-silica reinforced DGEBA-IMA composites offers a better corrosion resistant property due to the presence of more nitrogen atoms in imidazole derivatives and alkyl side chain in the cardanol moiety. It helps to improve the water contact angle of DGEBA-IMA composites and in turn contributes to an enhanced corrosion resistant behavior.
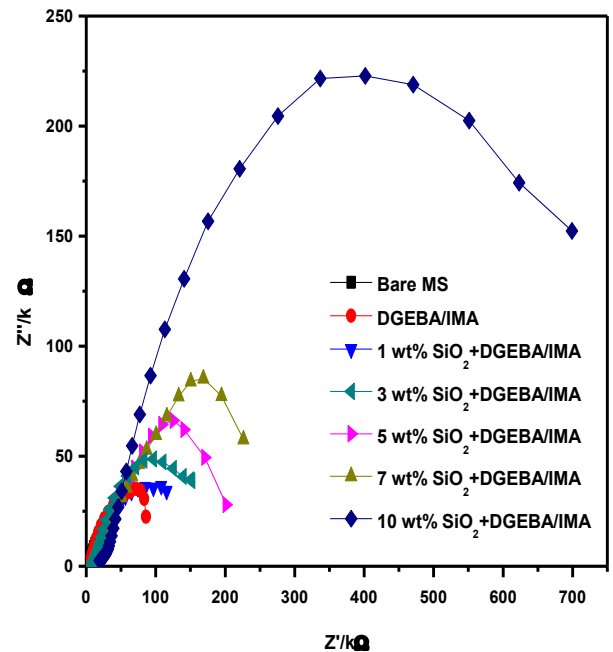

Fig. 5: EIS response of bare MS and bio-silica reinforced DGEBA–IMA composites coated specimen in 3.5% NaCl solution
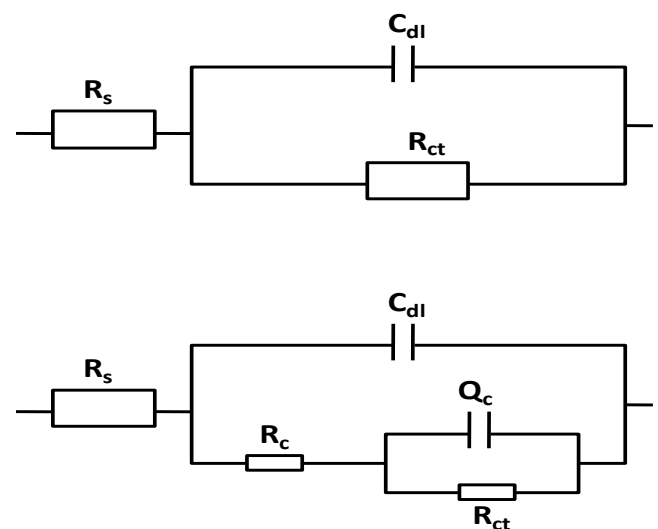

Fig. 6: The equivalent circuit used for impedance analysis

Fig. 7 represents the Tafel plots and the values of the corrosion parameters for the coated MS specimens are given in table 3. The curve a represents the Tafel plot of uncoated specimens while curves a-d represent the Tafel plot of the coatings loaded with the different amount of bio-silica reinforced DGEBA-IMA composites. The corrosion rate (CR) was calculated using I_{corr} values in the equation (2),

$$CR = MI_{corr} / \rho nF \qquad (2)$$

Where, M is the molecular mass of copper (58.69 g mol⁻¹), I_{corr} is the corrosion current density (Acm⁻²), F is the Faradays constant (96500 A s mol⁻¹), ρ is the density of the mild steel specimen (7.85 g cm⁻³), and the number of electrons transferred during corrosion reaction is assumed to be 2 [14].

The E_{corr} values of the polymer coated samples are increased anodically and Icorr values the coated specimens are reduced by indicating that corrosion resistance of the coated specimens are improved after coating. This Effect is more pronounced when bio-silica are loaded in the coating. The improved corrosion resistance may be due to the suppression of the anodic corrosion reactions by the bio-silica reinforcement [15]. The 10 wt% bio-silica reinforced DGEBA-IMA composites coating shows the better positive shift in terms of Ecorr value and lower corrosion current. Data obtained from corrosion studies, it is inferred that the presence of nitrogen rich imidazole core based IMA moiety influence the corrosion resisting behavior.
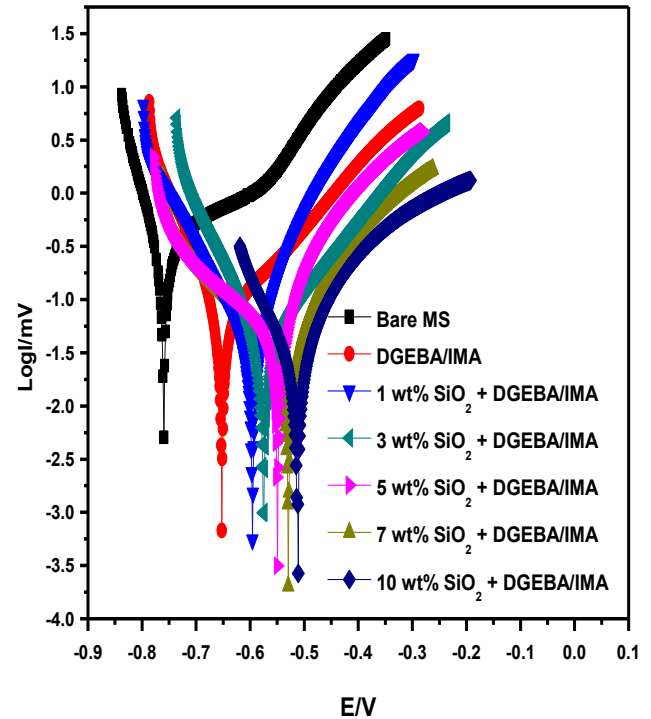

Fig. 7: Tafel plots of bare MS and bio-silica reinforced DGEBA-IMA composites coated specimens in 3.5% NaCl solution

Table 3: The values of the corrosion parameters of the coated and uncoated mild steel specimens in 3.5 % NaCl solution calculated from Tafel studies

Specimens	E_{corr} (mV)	I_{corr} (μA)	CR mm year⁻¹	Efficiency η (%)
Bare	-752	1350	0.05229629	0
Neat DGEBF/IMA	-651	83.536	0.00323602	93.81
1 wt% SiO₂ DGEBF/IMA	-596	52.491	0.0020334	96.11
3 wt% SiO₂ DGEBF/IMA	-576	41.432	0.00160499	96.93
5 wt% SiO₂ DGEBF/IMA	-551	40.724	0.00157757	96.98
7 wt% SiO₂ DGEBF/IMA	-533	34.100	0.00132097	97.47
10 wt% SiO₂ DGEBF/IMA	-514	40.586	0.00157222	96.99

4. CONCLUSION

The present work is to develop bio-silica reinforced epoxy composite coatings to utilize them for protection of mild steel surfaces from corrosion. In this context, Imidazol core monoamine (IMA) was synthesised and used as a hardener for epoxy resin. The epoxy resin was reinforced with varying weight percentages of 3-glycidoxypropyltrimethoxysilane (GPTMS) functionalized rice husk ash bio-silica to obtain respective composites. Their composite morphology and thermal stability was studied using SEM analysis thermo gravimetric analysis (TGA). The values of limiting oxygen index calculated from TGA data infer that all the samples of epoxy matrix and composites possess good flame retardant behaviour. In order to ascertain their hydrophobic behaviour, the water-contact angle measurement studies were carried out. The values of contact angle obtained for neat IMA/DGEBA matrix is 84°, where as that of 1, 3, 5, 7 and 10wt% bio-silica reinforced IMA/DGEBA are 87°, 90°, 93°, 95° and 98° respectively. IMA/

DGEBA matrix and functionalised bio-silica reinforced IMA/DGEBA composites were coated on the mild steel specimens and their corrosion resisting behaviour was studied by electrochemical impedance spectroscopy and potentiodynamic polarisation. Data resulted from corrosion studies (Nyquist plot and Tafel plot), inferred that among the coated specimens studied, the specimen coated with 7 wt% bio-silica reinforced IMA/DGEBA matrix exhibits the highest corrosion resisting efficiency.

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