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Studies of anticorrosive performance of ginger extract in epoxy coating

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ABSTRACT

Extract of ginger has been prepared using dimethyl formamide (DMF) as a solvent. The major component of ginger which is obtained in extract also is gingerol, having –OH functionality as a structural part. The extract in solution form in DMF has been added into epoxy-amine system as well as in epoxy-Melamine formaldehyde (MF) system. With addition of the extract, corrosion resistance has been increases as compared to the plain epoxy system. It is observed as epoxy-MF system gives better anticorrosive properties as compared to the epoxy-amine system. The reasoning for the same is that in epoxy-amine system the gingerol remains as a physical constituent to improve the anticorrosive performance. Whereas, in case of epoxy-MF system, the –OH functionality of gingerol interacts with MF resin and hence while curing the gingerol becomes the chemically intact in resin backbone system. It affects the coating performance significantly hence epoxy-MF system shows better anticorrosive performance over epoxy-amine system.

Keywords : Ginger, anticorrosive coating, green inhibitors, natural resources, epoxy

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INTRODUCTION

Anticorrosive coating is one of the important segments of coating industry. Since it helps to avoid the economic losses due to the corrosion and help to avoid the structural damage of steel structures such as bridges, automobiles etc. Among the various approaches of anticorrosive

coating, the natural product for corrosion protection is emerging area. The benefits of such approach is, it is ecofriendly in nature, renewable resources available at low cost etc. [01-04]

Various natural products have been studied for anticorrosive application such as leaves, root, seeds extracts of various plants. Mango, orange leaves, black pepper extract, karaj seed extract, caffeine, neem etc. has been studied for anticorrosive application. This extracts are rich in oxygen, nitrogen and sulphur compounds. These compounds tend to enhance the anticorrosive performance hence they can be successfully used as corrosion inhibitors.[04-05]

Ginger (zingiber officinale), is from the family of Zingiberaceae, haves thick tuberous rhizomes. Various uses of ginger has been explored such as in antioxidant, medical application, antimicrobial application.[06-08]

Here in this study, extraction of ginger has been done in dimethyl formamide (DMF) as solvent. The extract in solution form has been used as solvent system for epoxy-amine and epoxy- MF coating system. Hence ginger modified epoxy coatings have been made and coatings have been studied for anticorrosive performance.

EXPERIMENTAL PROCEDURE

Materials

Ginger roots obtained from local market. It was cleaned properly to remove any dust, dirt, mud from its surface. The roots has been dried and then grinded in the mixer to make a fine powder of the same. DMF, p-toluenesulphonic acid (p-TSA) is obtained from S.D.Fine India Pvt. Ltd. Epoxy resin is obtained from Grand Polycoat Pvt. Ltd. Amine hardener obtained from Dow corning company Pvt. Ltd. Butylated MF resin is obtained from Kansai Nerolac Pvt. Ltd. All the materials used as obtained without any purification.

Extraction of Ginger

The ginger powder obtained from above method is added into single necked flask. The DMF solvent is added into the same. The ratio of ginger powder to solvent is for 12.5 gm of powder 100 ml of solvent has been added. The flask has been kept on magnetic stirrer and stir for 1 hour for better dispersion and wetting of powder surface with the solvent. Then the mixture has been kept as such stand by for 24 hours. After completion of 24 hours, the filtration is done and the filtrate obtained is ginger extract and it used as such as solvent in coating system.

Synthesis of coating

The epoxy is uses as base resin and performance of two hardeners has been studied i.e. amine and MF system. The coating is applied on mild steel panel. The panels were first wipe out to remove any dirt, dust, oil etc. Then rub with the sand paper to create surface roughness. In the next step, wipe out with solvent i.e. acetone. This completes the panel preparation. For coating system, in case of epoxyamine system the ratio of base resin : hardener is 10 : 3. The total batch size is measured by considering the total binder system i.e. epoxy resin plus hardener. The solvent quantity is added exactly same as that of total batch size. Means, for 4 gm of batch, 4 gm of solvent has been added. For plain coating firstly, epoxy resin has been weighed, the required quantity of solvent i.e. pure DMF has been added into the same. Mix it properly. Then amine is added into the same, stir properly and applied on panel. The curing is takes place at room temperature for 24 hours. In case of ginger modified system, instead of pure DMF, the extract has been added into the coating. For epoxy-MF system, p-TSA has been used as catalyst and has been added 0.5% of total batchsize. Firstly, p-TSA has been dissolved in solvent system. Epoxy resin has been weighed, solvent has been added, stir properly and the MF resin has been added. MF resin has been used 40% of epoxy on weight basis. The panel has been applied and flash off time of 10 minutes is allowed, then curing is done at elevated temperature. First, was at 100°C for half n hour and then at 150°C for one hour. The testing has been carried out on both the panels after 7 day. The formulations of batches represented in Table1

Table 1 : Formulations of coating								
Sr. No.	Batch code	Details of batch						
1.	Batch 1	Plain epoxy-amine system						
2.	Batch 2	Ginger modified epoxy-amine system						
3.	Batch 3	Plain epoxy-MF system						
4.	Batch 4	Ginger modified epoxy-MF system						

RESULTS

FTIR

FTIR of ginger extract has been done by ATR-FTIR method and represented in Figure 1. The major component of ginger extract is gingerol. The structure for the same is represented in Figure 2. As shown in the figure, it has aromatic linkage, long alighatic chain and hydroxyl group present on

the structure.



Figure 1: FTIR of ginger extract

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The peak observed 2880 cm⁻¹ and 2950 cm⁻¹ represents the C-H stretching. Peak observed at 3370 cm⁻¹ represents –OH stretching. The C-O stretching appears at 1030 cm⁻¹. The C=O stretching appears at 1650 cm⁻¹. This confirms that gingerol has been successfully extracted from ginger.



Gingerol

Figure 2 : Structure of gingerol

Mechanical Properties

The result for mechanical properties of the coating has been shown in Table 2. All coating passes adhesion test successfully. As seen from table, the scratch resistance and pencil hardness increase with ginger modification. This could be due to incorporation of aromatic moiety of g ingerol which tends to improve the hardness properties of the coating. The impact resistance is observed to be excellent for all systems. This indicates good load bearing capacity of the system. The aliphatic linkage of gingerol also slightly helps to improve the load bearing capacity even though it has aromatic linkage present in it. All coating pass flexibility test successfully, it indicates ginger modification does not affect inherent flexible properties of epoxy adversely.

Sr.No.	Properties	Batch 1		Batch 2		Batch 3		Batch 4	
1.	DFT	100±05 µm		100±05 µm		100±05 µm		100±05 µm	
2.	Cross hatch adhesion	5B		5B		5B		5B	
3.	Scratch resistance (Kg)	3.2		3.5		3.4		3.6	
4.	Pencil hardness	2H		3H		2H		3H	
5.	Impact resistance (Kg-	F.I.	B.I.	F.I.	B.I.	F.I.	B.I.	F.I.	B.I.
	cm)	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6
6.	Flexibility (mm)	0		0		0		0	

Table 2 : Mechanical properties of the coating

Chemical Resistance

The resistance of the coating is checked against acid, alkali and solvent. The 5% HCl and 5% NaOH (w/w) aqueous solution has been used to check acid and alkali resistance respectively. The test has been done for 24 hours duration. The solvent resistance is check by solvent rub method against MEK and xylene. The acid and alkali resistance found be excellent for both epoxy- amine and epoxy-MF system. There is no loss of adhesion, any softening, blistering, loss of gloss observed in the system. This is due to the excellent curing in both epoxy-amine and epoxy-MF system. Curing develops the three dimensional structure, all functional groups get reacts hence system can develop excellent resistance against acid and alkali. The solvent resistance also observed to be good and no above mention defects has been observed. Since due to the curing, the three dimensional crosslinked structures have been developed, hence no swelling or dissolution of polymeric chains can be possible. Hence coating develops excellent solvent resistance.

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Anticorrosive properties

Anticorrosive properties have been evaluated by salt spray and EIS analysis. The salt spray test has been conducted with 5% NaCl aqeous solution for the duration of 1500 hours. The result for the salt spray analysis has been shown in Figure 3. EIS analysis has been carried at 0 hours and after immersion the coated sample in 3.5% NaCl solution for 125 hours. Result for EIS analysis for epoxy-amine system has been shown in Figure 4 and for epoxy-MF system shown in Figure 5. As seen from the photographic reference with ginger modification anticorrosive performance has been observed. The highest impedance value has been shown by ginger modification in both epoxy- amine and epoxy-MF system. The difference impedance value for plain epoxy and ginger modified epoxy is not high before immersion. But after immersion the ginger modified systems maintain their impedance value decrease drastically. The impedance value observed to be ~ 5G for both plain and modified coating before immersion. But after immersion the ginger modified system has shown

impedance value ~5G which drops down for plain epoxy ~ 1G in both the cases. This has proven ginger modified system can show better anticorrosive performance in corrosive media also.

The reason for the same is gingerol helps for increases the adhesion of coating to metal substrate. The lone pair present on oxygen atom helps interacts with vacant d orbital of ferrous metal of mild steel. Hence chemical adsorption takes place. This leads to improve the performance. Presence of aromatic linkage also tends to decrease the water attack hence attack of corrosive species gets reduce. The epoxy-MF shows better anticorrosive performance than epoxy-amine system. The reason for the same is, in epoxy amine system there is no functional group which can interact with the gingerol. In epoxy-MF system, the –OH functionality reacts with MF resin hence, gingerol gets added into coating backbone. The reaction scheme for the same is represented in Figure 6. Hence here, chemical modification takes place as compared just physical addition of gingerol in coating system. This helps to increase the anticorrosive performance.



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1 : Epoxy-amine coating before immersion, 2 : Epoxy-amine coating after immersion, 3 : Ginger modified epoxy-amine coating before immersion, 4- Ginger modified epoxy-amine coating after immersion



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1 : Epoxy-MF coating before immersion, 2 : Epoxy-MF coating after immersion, 3 : Ginger modified epoxy-MF coating before immersion, 4 : Ginger modified epoxy-MF coating after immersion



Figure 5 : EIS analysis of epoxy-MF system

Figure 6 : Curing of epoxy resin with MF in presence of gingerol

CONCLUSIONS

Epoxy coating has been successfully modified with the ginger extract. The main constituent of extract is gingerol. The performance has been studied in epoxy-amine system and in epoxy-MF system. The gingerol has lone pair of electron present on oxygen which can interact with vacant d orbital of ferrous metal. Hence adhesion of coating improves to the substrate. It is observed that better anticorrosive performance has been observed in epoxy-MF system than in epoxy-amine system. The gingerol gets chemically linked into the resin backbone in epoxy-MF system than in epoxy-amine where it presents as physical modifier only. The –OH functionality of gingerol reacts with MF resin hence gingerol become structural part of epoxy-MF system. The hardness properties increase with modification with ginger. Since an aromatic group gets incorporated in the system with ginger modification which tends to improves the hardness properties.

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