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Behavioural Studies of Nano Formulated Paints

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ABSTRACT- Mixed metal oxides are synthesized from corresponding oxides and are used as pigments in paints which constitutes the Nanoformulated paints. The behavioural studies of these Nanoformulated paints are investigated in various aspects. The studies show better hiding power and enhanced glossiness. Nanoformulated paint coatings are done on mild steel plate and the coatings were tested in corrosion atmosphere. The results of corrosion tests were compared with commercially available red and white paint. Also the corrosion behaviour was studied for TiO_2 and Fe_2O_3 formulated paint along with $TiO_2.Fe_2O_3$. The mixed metal oxides $TiO_2.Fe_2O_3$ shows better corrosion inhibition efficiency. The particle size of the prepared oxide nanoparticles are confirmed with SEM. The structural and functional purity of the oxides were confirmed with XRD and FTIR respectively. Furthermore the studies were extended by evaluating the photocatalytic behaviour of the prepared oxides. It is found that upon UV irradiation on the dye the photocatalytic degradation was significantly increased. This studies confirms that incorporation of these nanoparticles in paints enhances the photocatalytic activity which results in the reduction of volatile organic compounds.

KEYWORDS: Mixed Metal Oxides, Nanoformulated Paints, Glossiness, hiding power, Corrosion, Photocatalyticbehaviour

I.INTRODUCTION

Nanotechnology is the science of developing materials by controlling the individual atoms and molecules to create devices that are thousand times smaller than the current technology. They are the structures between 1nm and 100 nm in size. They achieve ethical challenges. It has been applied to many areas of study including electronic engineering, physical sciences, biomedical sciences and many others. Most paints include at least four groups of components: binders, volatile substances, pigments, and additives. In order to increase the efficiency of TiO_2 for photocatalytic activity is proposed to use mixed metal oxides to enhance photocatalytic behavior. The oxides such as Fe_2O_3 was doped with TiO_2 to form mixed metal oxides such as $Fe_2O_3.TiO_2$. These nanoparticles are incorporated into paints to enhance the photocatalytic behavior hence

reducing the volatile organic compounds contained in them. Furthermore, glossiness, hiding power and anticorrosion behavior are determined.

II.MATERIALS AND METHODS

2.1 Preparation of Metal Oxide Nanoparticles

The metal oxides such as TiO_2, ZnO, NiO, $Fe_2O_3$are prepared by SOL-GEL process. A colloidal suspension or a sol is formed due to hydrolysis and polymerization reaction of the precursors, which on complete polymerization and loss of solvent leads to the transition from liquid sol into a solid sol phase

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2.2 Preparation of Mixed Metal oxide Nanoparticles

The prepared metal oxides are taken individually in a beaker and distilled water is added. Based on their combination such as $TiO_2.Fe_2O_3$ two metal oxides are taken combined, heated in a hot plate at 60°C.Then it is washed, filtered and dried.

2.3 Preparation of Nanoformulated based paints

The paints are synthesized by mixing the composition of pigment, resin, solvent and additives in a equal proportion

Ingredients	Weight %
Total solids(pigments + additives)	50-70
Vehicle or medium	30-40
Solvents	20-40

Table 1: Composition of paint

2.4 Gloss Test

Gloss test is required to ensure uniformity of the surface finish. The gloss value is determined by directing a light, at the test surface and measuring the amount of specular reflection. Gloss is measured at 60°.

.Gloss level	Gloss at 60°
1	maximum 5 units
2	maximum 10 units
3	10-25 units
4	25-35 units
5	35-70 units
6	70-85 units
7	more than 85 units

Table 2: Gloss Level Measurements

2.5 Hiding Power

Opacity and hiding power measurement was done using quadruplex film applicator. It act as Multifunctional film applicator with 4 application sides for applying paint-films. It is placed near one end of a flat panel, like a test chart. A sufficient volume of paint/liquid is placed in front of the applicator. The applicator is then drawn down in the chart manually, which leaves a uniform film behind it.

2.6 Anticorrosion Studies

Corrosion is the destructive attack to metal by chemical or electrochemical reaction with its environment. Mild steel was easily corroded in acidic medium. To reduce this problem the corrosion inhibitor coating was done on it. A corrosion inhibitor is the material which inhibits the corrosion reaction by providing a protective barrier film which in turn stops the corrosive reaction. Paint is a material which prevents the direct contact of corroding media like air and H_2O over the metal surface. It forms a uniform thin layer after drying and protects the base metal from the corrosion

2.7 Photocatalytic behaviour studies

The photocatalytic behaviour in paints is studied under UV light.The photocatalytic degradation is due to absorbance of the peak. TiO_2 is a photocatalyst when it is illuminated by light of energy higher than its band gap, electrons in TiO_2 will jump from valence band to conduction band and electrons and holes will form on the surface of the photocatalyst. The negative electrons and oxygen will combine to form radical ions whereas positive electric holes and water will generate hydroxyl radicals OH^-Since both products use unstable chemical entities when the organic compound falls on surface of photocatalyst it will combine with O_2^- and OH and turns to form CO_2 and H_2O.

$$TiO_2 + h\gamma \longrightarrow TiO_2\ (e^- + h^+)$$

$$H_2O + TiO_2\ (h^+) \longrightarrow TiO_2 + OH + H^+$$

$$O_2 + TiO2\ (e^-) \quad TiO_2 + O_2^- \longrightarrow$$

III. CHARACTERISATION STUDIES

3.1 XRD analysis

The structural features of $TiO_2.Fe_2O_3$ is explored from XRD data. In Fig 3.1 the XRD pattern of final powders revealed well developed reflection of $TiO_2.Fe_2O_3$ nanoparticles (JCPDS.No 89-8104, 89-6975, 89-4920.).

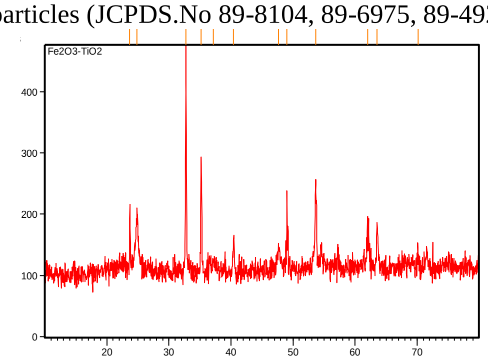

Fig 1:XRD pattern of $Fe_2O_3.TiO_2$

3.2 SEM analysis

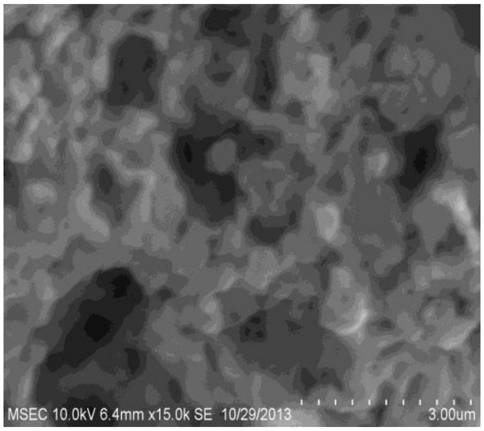

Fig 2: SEM imageof $Fe_2O_3.TiO_2$

This figure reveals the presence and uniformity of the distributed particles. It was clear that the particles obtained were in nano size ranging in the diameter from 150-200nm.

3.3 AFM analysis

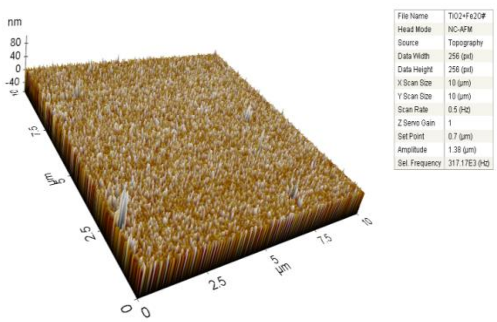

Fig 3: AFM imageof $Fe_2O_3.TiO_2$

It represents the 3D AFM images of the $TiO_2.Fe_2O_3$ coatings. The shape and thickness of the coated particles is around 80nm and it is uniformly distributed.

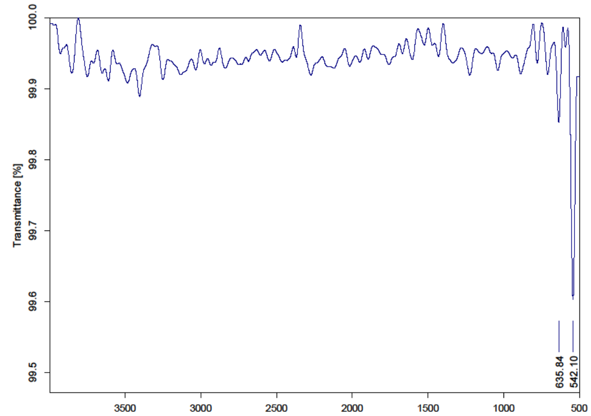

Fig 4: FTIRof $Fe_2O_3.TiO_2$

FT-IR spectrum TiO_2nano particles (fig 5.10) showed significant absorption peaks at 990cm^{-1}&1648cm^{-1}.The absorption band 990cm^{-1} was assigned to Ti-O stretching vibration. The weak band near 1648cm^{-1}is assigned to H-0-H bending vibration

IV. EXPERIMENTAL RESULTS

4.1 Glossiness

Sample		**Glossiness in Units**
Nanoformulated paints with respective pigments	TiO_2 paint	78
	Fe_2O_3 paint	72
	$TiO_2.Fe_2O_3$ paint	86

Table 3:**Glossiness Values for VariousNanoformulated Paints**

4.2 Hiding Power

Paint Sample		Chart Weight B (g)	Chart Weight With Paint W (g)	Chart Weight After It Is Rubbed With (g)	Coverage Area A inch/cm^2	Hiding Power (W-B) /A gm / (inch)^2
Nanoformulated paints	TiO_2	15.54	16.54	15.97	0.4625	2.16
	Fe_2O_3	15.54	16.55	17.14	0.5	2.02
	$TiO_2.Fe_2O_3$	15.54	16.61	16.39	0.35	3.05

Table 4: Hiding Power for Various Nanoformulated Paints

4.3 Solid Content of Paints

Sample		Weight of empty hlass slide W (g)	Weight of glass slide with paint W_2 (g)	Weight of glass slide after I hr heating W_3 (g)	W_3 -W_1 (g)	W_2 -W_1 (g)	Percentage of solid content in paint $((W_3\text{-}W_1) / (W_2\text{-}W_1))$ (%)
Nanoformulated paints	TiO_2 paint	6.192	6.422	6.383	0.191	0.23	83.04
	Fe_2O_3 paint	6.192	6.485	6.364	0.172	0.293	58.70
	$TiO_2.Fe_2O_3$ paint	6.192	6.544	6.508	0.316	0.352	89.77

Table 5:Solid Content for Various Nanoformulated Paints

4.4 Photodegradationof Nanoparticles

S.no	Time (mts)	Wavelength (nm)	Absorbance
1.	10	517.3	3.319
2.	20	517.3	2.27
3.	100	458	0.502
4.	140	458	0.394
5.	150	458	0.035

Table 6 :Photodegradtion of dyes by $TiO_2.Fe_2O_3$ nanoparticle

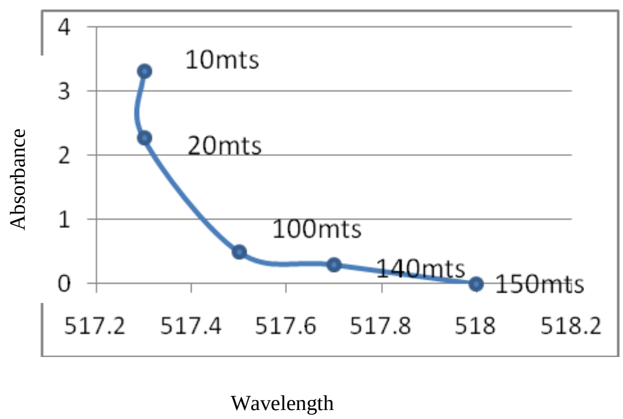

Fig 5 Photodegradtion of dyes by $TiO_2.Fe_2O_3$ nanoparticle

4.5 CorrosionBehaviour

Sample	Initial weight W_1	Final weight W_2	Weight loss W_0= W_1-W_2	Corrosion rate C.R=((weight loss x 372) / (Area x time))
	(g)	(g)	(g)	(mg/dm^2)
Uncoated steel	19.150	19.100	0.050	0.0021

Table 7:Corrosion behaviour of uncoated steel

Sample	Initial weight W_1	Final weight W_2	Weight loss W_0= W_1-W_2	C.R=((weight loss x 372) / (Area x time))	Inhibition efficiency IE=((W_0-W) / W_0)) x100
	(g)	(g)	(g)	(mg/dm^2)	(%)
Steel coated with TiO_2 paint	23.800	23.780	0.020	0.00062	3
Steel coated with Fe_2O_3 paint	24.050	24.020	0.030	0.00099	2
Steel coated with TiO_2.Fe_2O_3 paint	24.000	23.985	0.015	0.00049	37
Steel coated with white paint	24.050	24.015	0.035	0.0011	1.5
Steel coated with red paint	24.050	24.010	0.040	0.0013	1

Table 8:Corrosion behaviour of paint coated steel

V. CONCLUSION

Nanoformulated paints such as titanium oxide, iron oxide and mixed oxides were prepared. The properties for both nanoformulated paints and commercially available paints are analysed. Glossiness, SolidContent and Hiding power of Nanoformulated paints are higher when compared to commercial paints. Corrosion behaviour is low in Nanoformulated paints and therefore it has high inhibition efficiency.

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