

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 TiO₂ and Fe₂O₃ formulated paint along with TiO₂.Fe₂O₃. The mixed metal oxides TiO₂.Fe₂O₃ 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

1.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 TiO₂ for photocatalytic activity is proposed to use mixed metal oxides to enhance photocatalytic behavior. The oxides such as Fe₂O₃ was doped with TiO₂ to form mixed metal oxides such as Fe₂O₃.TiO₂. 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 TiO₂, ZnO, NiO, Fe₂O₃ 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

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 TiO₂.Fe₂O₃ 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

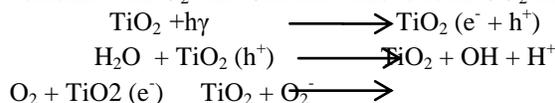
Opacity and hiding power measurement was done using quadruplex film applicator. It act as Multifunctional film applicator with 4 application sides for applying paint-films. It is placed near one end of a flat panel, like a test chart. A sufficient volume of paint/liquid is placed in front of the applicator. 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 H₂O 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. TiO₂ is a photocatalyst when it is illuminated by light of energy higher than its band gap, electrons in TiO₂ 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 O₂⁻ and OH and turns to form CO₂ and H₂O.



III. CHARACTERISATION STUDIES

3.1 XRD analysis

The structural features of TiO₂.Fe₂O₃ is explored from XRD data. In Fig 3.1 the XRD pattern of final powders revealed well developed reflection of TiO₂.Fe₂O₃ nanoparticles (JCPDS.No 89-8104, 89-6975, 89-4920.).

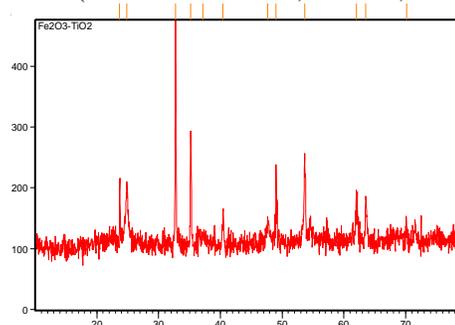


Fig 1: XRD pattern of Fe₂O₃.TiO₂

3.2 SEM analysis

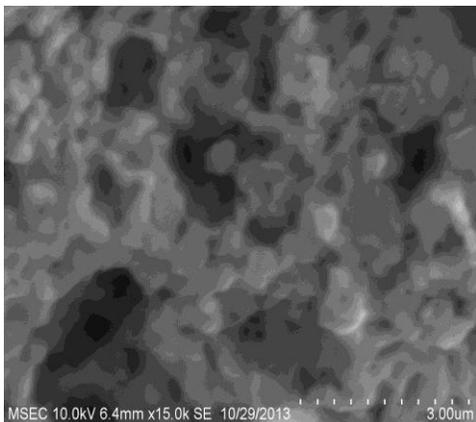


Fig 2: SEM image of $\text{Fe}_2\text{O}_3.\text{TiO}_2$

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

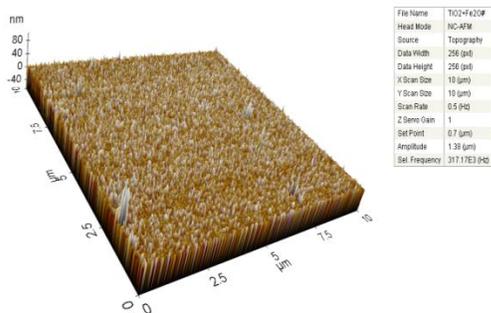


Fig 3: AFM image of $\text{Fe}_2\text{O}_3.\text{TiO}_2$

It represents the 3D AFM images of the $\text{TiO}_2.\text{Fe}_2\text{O}_3$ coatings. The shape and thickness of the coated particles is around 80nm and it is uniformly distributed.

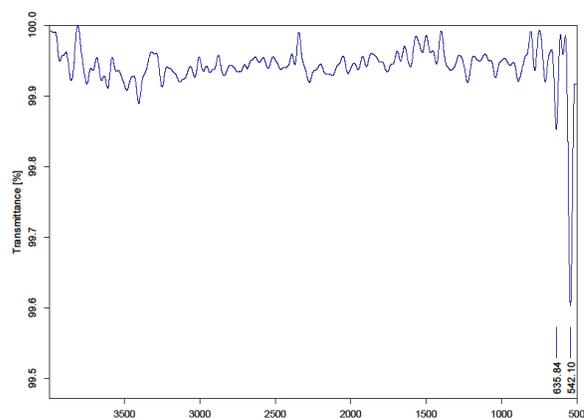


Fig 4: FTIR of $\text{Fe}_2\text{O}_3.\text{TiO}_2$

FT-IR spectrum TiO_2 nano 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-O-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
	$\text{TiO}_2.\text{Fe}_2\text{O}_3$ paint	86

Table 3: Glossiness Values for Various Nanoformulated Paints

4.2 Hiding Power

Paint Sample		Chart Weight	Chart Weight	Chart Weight	Coverage Area	Hiding Power (W-B) /A
		Chart B	Chart With PaintW	Chart After It Is Rubbed With		
		(g)	(g)	(g)	inc h/c m ²	gm / (inch) ²
Nanoformulated paints	TiO ₂	15.54	16.54	15.97	0.4625	2.16
	Fe ₂ O ₃	15.54	16.55	17.14	0.5	2.02
	TiO ₂ ,Fe ₂ O 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 glass slide, W ₁	Weight of glass slide with paint W ₂	Weight of glass slide after 1 hr heating, W ₃	Percentage of solid content in paint ((W ₃ -W ₁) / (W ₂ -W ₁))	
		(g)	(g)	(g)		(g)
Nanoformulated paints	TiO ₂ paint	6.192	6.422	6.383	0.191	83.04
	Fe ₂ O ₃ paint	6.192	6.485	6.364	0.172	58.70
	TiO ₂ ,Fe ₂ O ₃ paint	6.192	6.544	6.508	0.316	89.77

Table 5: Solid Content for Various Nanoformulated Paints

4.4 Photodegradation of 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 :Photodegradation of dyes by TiO₂,Fe₂O₃ nanoparticle

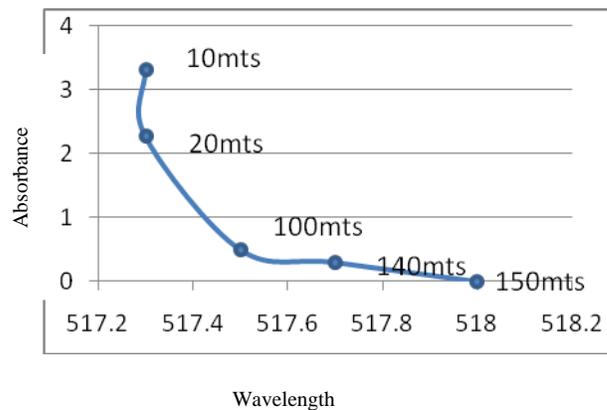


Fig 5 Photodegradation of dyes by TiO₂,Fe₂O₃ nanoparticle

4.5 Corrosion Behaviour

Sample	Initial weight W_1	Final weight W_2	Weight loss $W_0 = W_1 - W_2$	Corrosion rate $C.R = ((\text{weight loss} \times 372) / (\text{Area} \times \text{time}))$
	(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 $W_0 = W_1 - W_2$	$C.R = ((\text{weight loss} \times 372) / (\text{Area} \times \text{time}))$	Inhibition efficiency $IE = ((W_0 - W) / W_0) \times 100$
	(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	[4]
Steel coated with $\text{TiO}_2, \text{Fe}_2\text{O}_3$ paint	24.000	23.985	0.015	0.00049	[5]
Steel coated with white paint	24.050	24.015	0.035	0.0011	[6]
Steel coated with red paint	24.050	24.010	0.040	0.0013	[7]

[11]

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, Solid Content 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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