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Development of Coloured Emulsion Paints with IR Resistant Coatings over Asbestos sheets

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Abstract

The sun radiates energy in a wide range of wavelength. Most of the solar radiation that reaches earth is made up of visible and infra light. These radiations are absorbed by buildings and responsible for discomfort in living houses and working environment. Therefore energy consumption and their expenditure rise up, for cooling the buildings to have easing life. A new innovative water borne emulsion special coating is formulated using IR reflective pigment blending with acrylic resin for colour coating over asbestos sheet is promising to reflect the radiations in the UV/NIR spectrum. The morphology of the coating is examined using SEM with EDX. The coated panels are tested for IR reflectivity and finally the UV/Vis/NIR reflectance for the coated panel is evaluated. The results indicate an effective coating to reflect NIR and decrease the building temperature when used as exterior emulsions.

Keywords: *IR reflective pigment, water borne emulsion paint, reflect NIR spectrum.*

1. Introduction

Solar radiation is all of the light and energy that comes from the sun, and these are many different forms. The most important parts of the sunlight electromagnetic spectrum are ultraviolet radiation (UV), invisible to the eye, visible light that allows us to see, and infrared radiation, which is our main source of heat but is also invisible. The sun is sending us radiation over a wide range of wavelength at varying intensities. It ranges from 295-2500 nanometers (nm) [1-3]. The foremost purpose of IR-reflective coatings is to keep objects cooler than they would be using standard pigments. The easiest way to increase IR reflectivity is to use white pigments like titanium dioxide. TiO_2 reflects in the visible and in the infrared. But there is a interest to produce colored IR-reflective coatings is to use pigments that absorb in the visible to produce color and reflect in the IR for coolness. The effective coating should meet infrared reflectivity and long-term durability requirements and provide deep and rich colors [4-8]. This formulation is find use to stay cool is a valuable benefit.

Infrared reflective pigments are complex pigments, which reflect the wavelengths in infrared region. The reflectivity and absorptivity of the pigment are independent of each other. These pigments are highly stable and chemically inert, also stable to high temperatures. They even remain colorfast in the presence of strong acids, bases, oxidizing or reducing agents. Because of these properties, these pigments last as long as 30 years in outdoors. IR reflective pigments do not absorb in near infrared region. They either reflect it or transmit it. Absorption of light occurs when light energy promotes electrons from one bonding state to another. If light of a different wavelength is used to cause this energy transition, it will not be absorbed. There is no method to predict the IR reflectivity of an inorganic or organic compound. This property appears to be an inherent characteristic property [9-12]. In the existing work water borne air-dry acrylic was used to make coatings with varied-to-binder ratios. The formulation is made to reflect UV/IR with the inclusion of fluorocarbon as a promising IR reflective pigment along with other additives. The new coatings was developed with light fast yellow colour coating. It is then applied over the asbestos sheet with different varied PVC concentrations. The

samples were compared and characterized by measuring the spectral reflectance [13-23].

2. Experimental details

2.1 Chemicals

Rutile, Soap stone, $CaCO_3$, acrylic resin, Texanol, IR reflective agent(choloroflurocarbon), wetting agent, fungicide, biocide, surfactant, acrylic thickener were purchased from Merck. TKA High pure water used.

2.2 Preparation of paint

The pigments were used as received and only dispersed (not ground) for preparation of the paints. The formulation of 30%, 40% and 50% are prepared as follows

Ingredients	30%	40%	50%
Demineralised water	13	13	13
Wetting agent	0.3	0.3	0.3
Fungicide	0.3	0.3	0.3
Biocide	0.3	0.3	0.3
Surfactant	0.3	0.3	0.3
Acrylic thickener	0.6	0.6	0.6
Demineralised water	20	20	16
Rutile	17	17	11
1000 mesh soap stone	6.5	17	17.5
1000 mesh $CaCO_3$	6.5	18	17.5
Acrylic resin	44	35	32
Texanol	0.7	0.7	0.7
IR reflective agent (flurocarbon)	0.3	0.3	0.3

After the complete formulation of the paint, they were applied with a brush in two layers over the asbestos sheet.

2.3. Characterization

The surface morphological studies have been investigated using Scanning electron microscope (Carlzeiss Model EV018) and the EDX (Bruker Xflash 6130). The UV/VIS/NIR spectrometer (carry 5000: version=1.12) used to measure the % of reflectance in Asbestos sheet. The viscosity of the coating is determined by Brook field-spindle number 2.

3. Results and discussion

3.1.1 Scanning Electron Microscopy (SEM)

Fig. 1 shows the SEM image of IR resistant coated Asbestos sheet in different concentration of PVC (30, 40 and 50 %). The coating was intact and there was not obvious degradation observed. The mean size of the particle is less than 100nm. The presence of elements is confirmed with EDX.

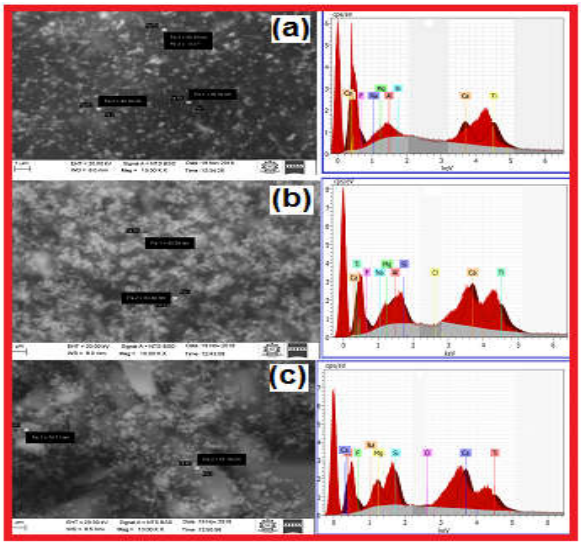

Fig. 1. *SEM with EDX of (a) IR resistant coated Asbestos sheet (30% PVC) (b) IR resistant coated Asbestos sheet (40% PVC) (c) IR resistant coated Asbestos sheet (50% PVC).*

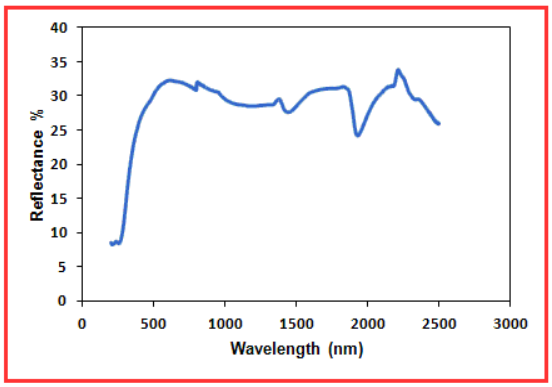

Fig. 2. *UV/VIS/NIR reflectance spectra of Blank Asbestos sheet*

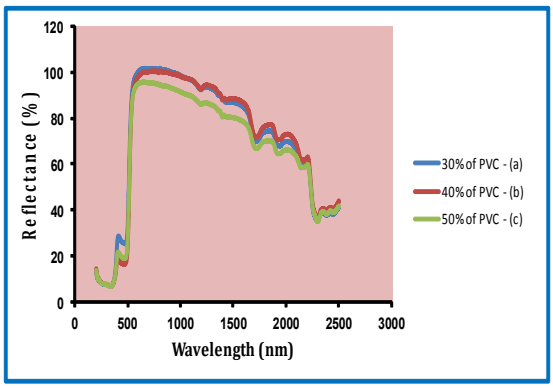

Fig. 3. *UV/VIS/NIR reflectance spectra of (a) IR resistant coated Asbestos sheet (30% PVC) (b) IR resistant coated Asbestos sheet (40% PVC) (c) IR resistant coated Asbestos sheet (50% PVC).*

3.2 Physical properties

3.2.1 Determination of viscosity

The viscosity of the coating is determined by using the Brook field – spindle number 2. The specific gravity is found experimentally by using the formula

$$DP = \frac{WFP \quad WF}{50\ ml \quad \frac{WFPL \quad WFP}{DL}} \qquad (1)$$

Where WFP-Weight of flask and powder, WF-Weight of flask, WFPL-Weight of flask, powder and wetting vehicle, DL-Density of wetting vehicle, DP-Specific gravity of powder

Table 1: The prepared IR resistant paint was initially tested for physical properties.

S.No	PVC (%)	Specific gravity	Viscosity of the paint	Total solid of the paint (%)
1	30	1.31	8 to1000 CPS	55
2	40	1.41		60
3	50	1.47		65

3.2.2 Total solid of paint

Total solid of paint is calculated using the following equation:

$$\text{Total solid of paint} = \frac{(\text{Volume of pigment} + \text{Volume of solid binder}}{(\text{Total volume of wet paint})} \times 100 \qquad (2)$$

The pigment and binder of paint form the volume solids of the dry paint film after the vehicle and some additives evaporate and are considered the real volume of the paint.

3.3 UV, VIS and NIR reflectance

The IR resistant coated paint reflectance is measured by using UV/VIS/NIR spectrometer (carry 5000: version=1.12). The coating is represented as

Light fast yellow specimen
30% PVC coating – Y 1
40% PVC coating – Y 2
50% PVC coating – Y 3

From the above Fig. 2 & Fig. 3 the different PVC concentration at particular wavelength has been calculated. For plain asbestos initially the reflectance has nominal value of 9% and slight increase of 29% at IR region is observed. The spectral reflectance spectra (UV/ VIS and NIR) of the sample yellow with 30, 40 and 50% PVC are shown in the Table 2. Measurements are carried out according to ASTM E 903-12. Initially the reflectance of the near UV region is around 7-10% and it is nearly ranges to 20-26% at 400 nm. When it elevates to 700 nm there is a progressive and remarkable differences and reaches upto 90 to 96% of reflectance is achieved where it shows that fluorocarbon is a promising pigment for IR reflectance. From the above result Y2 (highlighted) seems to be a better coating and it is also finalised with the result of reflectivity of the infrared lamp.

The Philips PRA 38 IR Red (150W 230V reference E27 ES) infrared lamp is used to measure the reflectivity of the colour coating of the sample in Table 3. A distance of 30 cm is maintained between the sample and the lamp, two thermocouples were used to record the temperatures, one thermocouple is placed in front of the coated area and the other at the back of the uncoated area of the specimen. The plates were placed under infrared lamp during an hour to equilibrate the temperature. After this period the temperature was recorded. The temperature in front (coated) and in the back (uncoated) side of the samples was noted and the difference in temperature was used as an analytic of the performance of the pigments (infrared-reflective or not). The room temperature was kept constant in order to avoid accretion of heat in this space and to assure that the heat absorbed by the asbestos sheet plates was completely by irradiation and not by convection of the air in contact with the inner surface of the plates.

Table 2: *Solar reflectance of the paint film*

Sample	Near UV-VIS region 295-400 nm	Near IR region 400-700 nm	Mid IR region 700-1200 nm	Far IR region 1200-2500 nm
Y1	7.99-26.65	26.65-96.41	96.41-87.485	96.41-36.499
Y2	8.03-18.67	18.67-95.34	95.34-92.983	95.34-39.267
Y3	7.77-20.73	20.73-90.29	90.29-81.035	90.29-36.791

Table 3: *The temperature in front and behind painted panels*

Sample	Front of Panel Coated (°C)	Behind of Panel Uncoated (°C)	T	PVC
Y1	55	45	10	30
Y2	53	42	11	40
Y3	54	45	9	50

From the result, the temperature behind the coated panel is comparatively less to the temperature prevailed in the panel front. Therefore the formulated coating is assertive in reflecting the IR light for better cool pigment. When the

temperature difference varies with concentration, it shows a minor variation, although the 40% PVC is producing better result. Finally the Y2 pigment is considered to be the promising ratio for water emulsion colour coatings.

4. Conclusions

The asbestos sheet was coated with pleasing colour of light fast yellow pigment with fluorocarbon as a IR reflective agent with varied PVC. From the study it is concluded that the coating was intact and shows a promising result across UV/Vis/NIR reflectance and irradiated by an IR lamp. With these results the formulation of Y2 pigment can be coated for the buildings as a exterior emulsions for resident and industrial buildings. New Coatings will resist the UV/IR radiation and minimize the heat transfer into buildings. Longer life cycle compared with single pigment coated paints. The highlight of the coatings is produced 100% reflectance on asbestos sheet in visible region (400-700 nm) for all the concentration 30%, 40% & 50%. The acrylic resin blended with chlorofluorocarbon coatings will provide an overview of this innovative coating technology as well as an update on key energy-saving standards.

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