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RESEARCH ARTICLE

ECONOMICAL DEVELOPMENT OF IR COATINGS IN ASBESTOS SHEET

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ABSTRACT

A new innovative water based emulsion coating is prepared with IR resist inorganic pigment blending with acrylic resin. The highlight of this formulation is to resist UV and IR radiation which reflects much of the Sun's radiant energy - an important feature to designers, builders and building owners concerned about rising energy consumption costs and global warming. In this present work water based UV/IR resist paint is formulated in different concentrations (30, 40, 50 % of PVC) and coated over the asbestos sheet. The morphology of the coating is examined using SEM with EDx. The initial test of physical properties like specific gravity, total solid of the paint and viscosity are examined for the formulation. A UV/VIS/NIR spectrometer used to measure the % of reflectance in Asbestos sheet. The 100% reflectance observed in visible region of (400-700nm) and 95% of reflectance is observed in IR region with increasing wavelength of 700-1400nm respectively.

Key words: Acrylic, pigments, coatings, water, UV/IR resistance, formulation.

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INTRODUCTION

Water based paints are gaining immense popularity with the public's effort to avoid using paints that involve harmful solvents and dangerous chemicals in its application and cleanup. Whereas, water based paints grip well to almost any surface and are weather-resistant. The paints are less likely to attract the growth of mildew on it. It can be used on almost all types of surfaces without any pre-treatment. These paints have a less potent odor and take less time to dry. They don't become brittle over time and require less ventilation than other oil based paints. Water based paints are also known to have more elasticity than oil based paints (Shibe and Chawla, 2013; Coser *et al.,* 2015; Malshe and Bendiganavale, 2008; Levinson *et al.,* 2005 and Kaur *et al.,* 2012). Water based paints use water as the medium which carries the colour pigment to the surface that is being painted. By the time the paint dries, the solvent evaporates completely. These paints have very little risks for humans and animals around because the only thing that evaporates and enters the air is hydrogen and oxygen. However in the case of solvent-based paints, solvents like epoxy, release harmful organic chemicals in the air while drying which is harmful to humans and animals, especially children (Bendiganavale and Malshe, 2008; Sainz *et al.,* 2003; White, 2000; Hunter, 1987 and Nixon, 2004).

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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. The key to fight this "White Blight" and produce innovative, colored IR-reflective coatings is to use pigments that absorb in the visible to produce color and reflect in the IR for coolness. From these demands, Shepherd Color has developed a line of highly engineered products called Arctic® IR-reflective pigments. The Arctic line of pigments provides a palette of colors that allows the formulation of coatings and the design of materials to meet infrared reflectivity and long-term durability requirements, and provide deep and rich colors. (Keefe, 2006; Sliwinski *et al.,* 2002; Yanagimoto *et al.,* 2003 and http://www.ferro.com/Our+ Products/ Pigments/Pigment+ Systems/ US+ Products +and + Markets/Products/Cool+Colors+and+Eclipse.htm). Large buildings situated in hot regions of the Globe need to be agreeable to their residents. Air conditioning is extensively used to make these buildings comfortable, with consequent energy consumption. Absorption of solar visible and infrared radiations are responsible for heating objects on the surface of the Earth, including houses and buildings (Chang *et al.,* 1995). To avoid excessive energy consumption, it is possible to use coatings formulated with special pigments that are able to reflect the radiation in the near- infrared, NIR, spectrum (Haacke, 1976; Chang *et al.,* 1995; Sutter *et al.,* 2002 and Patton, 1998). Roughly 5% of the Sunlight that reaches the Earth's surface is in the form of ultraviolet (UV) (wavelength between 300 and 400 nm) which is the main responsible by the photo degradation of organic materials including organic coatings. Around 42% of the solar energy occurs in the visible region of the electromagnetic spectrum. Different colours are detected by the optical human system in the wavelength range from 400 to 700 nm. Some 53% of the total solar energy is in the infrared region (IR) whose wavelength ranges from 700 to 2500nm. Heat is a direct consequence of either visible or infrared radiation incident on an object. The heat-producing region of the infrared radiation ranges from 700 to 1100 nm (Berdahl, 1998; Ogorkiewicz, 1989 and Sliwinski, 2001). While the human eye is sensitive to only a small part of the electromagnetic spectrum, pigment interactions with wavelengths outside the visible can have interesting effects on coating properties. One key area of the spectrum is the infrared (IR), specifically the near infrared. While not visible to the human eye, a pigment's, and thus a coating's IR properties can affect usability and durability (Nilsson and Hallberg, 2001; Libbra *et al.,* 2011; Ryan, 2005; Shepherd Color Company, 2001; Uemoto *et al.,* 2010 and Nechviloval and Kalendova, 2015). The possible applications of water based Fluorocarbon paints are; Building products, Vinyl window and siding, Automotive application, Military application, Infrared reflection from fire. The benefits of ultra violet and infrared reflective coatings: longer life-cycle due to less polymer degradation and thermal expansion due to lower temperature, aesthetically pleasing colors, cooler to touch for better handling, improved system durability and less thermal degradation (Levinson *et al.,* 2010; Zinzi *et al.,* 2012 and Brassard *et al.,* 2012). In the present work water based UV/IR resist paint is formulated by using an inorganic pigment Chlorofluorocarbon. The different concentrations 30, 40 and 50 % of PVC is formulated and coated over the asbestos sheet. To impart the maximum reflectance in visible region and Infrared region with 30, 40 and 50% of PVC is studied.

Experimental Details

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.

Experimental Details

Preparation of paint

A water based acrylic emulsion paint was formulated with varying pigment volume concentration of 30%, 40% and 50% respectively. The additives, pigments, binders, resin and solvent were taken at required quantity. The additives like wetting agent, Fungicide, Biocide, surfactant was mixed with acrylic thickener. This thickener is one which increases the viscosity and gives stability to emulsion paints. Then the pigments rutile and chlorofluorocarbon were added at constant stirring. The other additives such as soap stone and $CaCO_3$ were also added. After some time the acrylic resin was decant in the attritor. Texanol is added for coalescent finish of the paint. The viscosity of the paint was adjusted with solvents and then paint was applied using brush on cleaned asbestos sheet. The first coating was dried for 8 hrs at room temperature and then the second coating was applied over the former coating to get a fine finish.

After one day the specimen was subjected to various tests. The IR resistant coated asbestos sheet represented in Figure.1

Formulation of IR resistant paint at 30% PVC

Ingredients	%
DEMINERALISED WATER	13
WETTING AGENT	0.3
FUNGICIDE	0.3
BIOCIDE	0.3
SURFACTANT	0.3
ACRYLIC THICKENER	0.6
DEMINERALISED WATER	20
RUTILE	17
1000 MESH SOAP STONE	6.5
1000 MESH $CaCO_3$	6.5
ACRYLIC RESIN	44
TEXANOL	0.7
IR REFLECTIVE AGENT (Chloroflurocarbon)	0.3

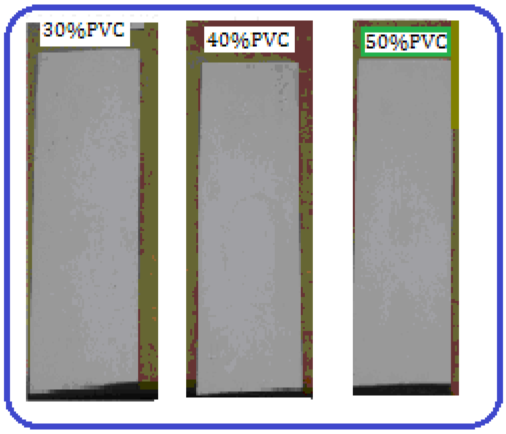


Fig. 1(a) IR resistant coated Asbestos sheet(30% PVC) (b) IR resistant coated Asbestos sheet(40% PVC) (c) IR resistant coated Asbestos sheet(50% PVC)

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.

RESULTS AND DISCUSSION

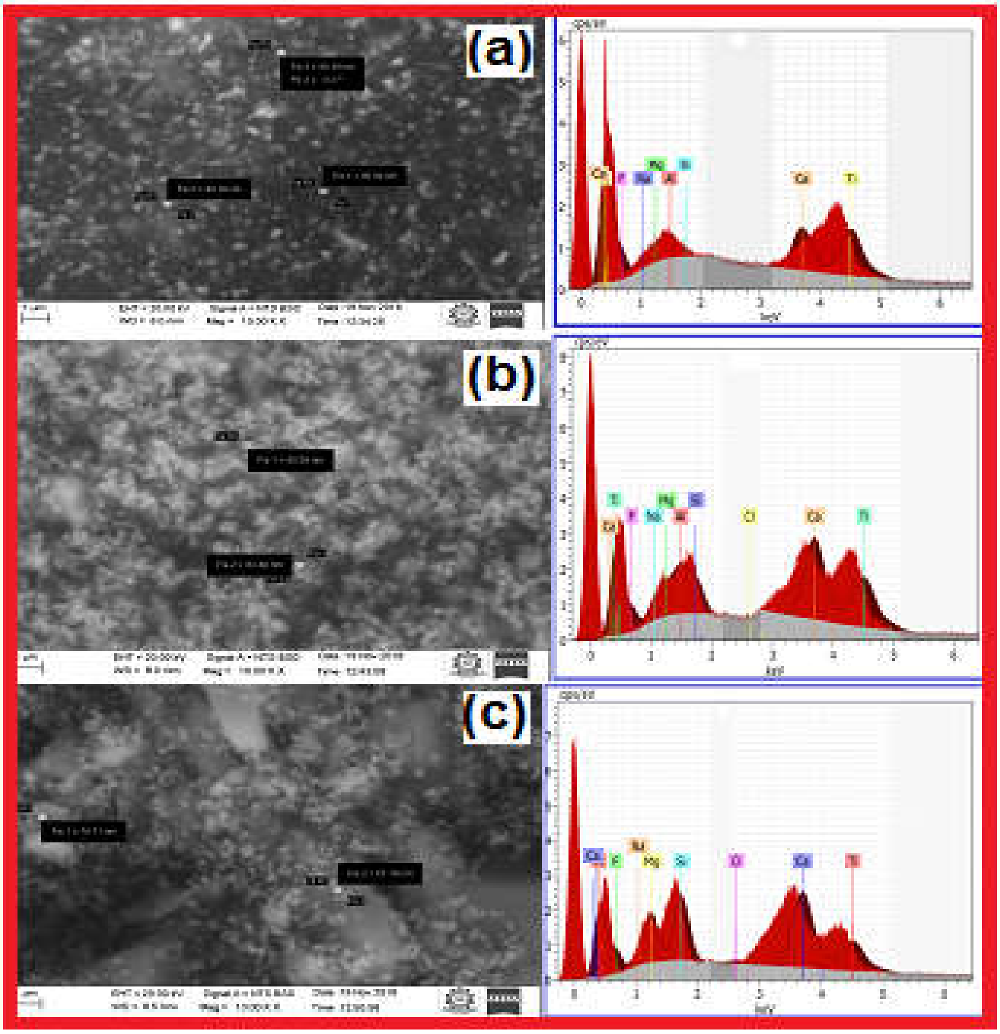
SEM

Fig. 2 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. PVC).

Physical properties

Determination of viscosity

The viscosity of the coating is determined by using the Brook field – spindle number 2. The specific gravity is found experimentally. Weigh the 50-mL volumetric flask. Record this weight as *WF*. Add 15 g of powder to the clean, dry, weighed flask and accurately reweigh. Record this weight as *WFP*. Add enough wetting vehicle to cover the powder and gently swirl until the powder is completely wet.



The removal of entrapped air has a significant effect on the accuracy of the results. Care should be taken to insure wetting out of the powder is complete. When necessary, stir the powder with a polished round-bottom glass rod until completely covered by the wetting vehicle. Wash the rod with wetting vehicle, adding the washings to the flask without exceeding the 50-mL calibration mark. Add additional wetting vehicle up to the 50-mL mark.

Fig. 3. Determination of viscosity by BROOK FIELD – SPINDLE NUMBER 2

Make sure that the bottom of the meniscus is aligned at eye level with the line on the front and back of the flask neck. This addition of wetting vehicle can be done with a squeeze bottle in a manner to wash any residual powder from the neck of the flask. Reweigh and record this weight as *WFPL*. Multiple volumetric flasks can be used in rotation to reduce cleaning and complete drying time. Each flask shall be completely clean and dry before proceeding to the next test.

The specific gravity can be calculated as follows

$$\frac{WFP - WF}{50ML - \frac{WFPL - WFP}{DL}}$$

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

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

Total solid of paint

Total solid of paint is calculated using the formula
= (Volume of pigment + Volume of solid binder) / (Total wet paint volume) × 100

S.No	PVC (%)	Specific gravity	Viscosity of the paint	Total solid of the paint (%)
1	30	1.31		55
2	40	1.41	8 to 1000 CPS	60
3	50	1.47		65

Fig. 4. UV/VIS/NIR spectrometer (carry 5000: version=1.12)

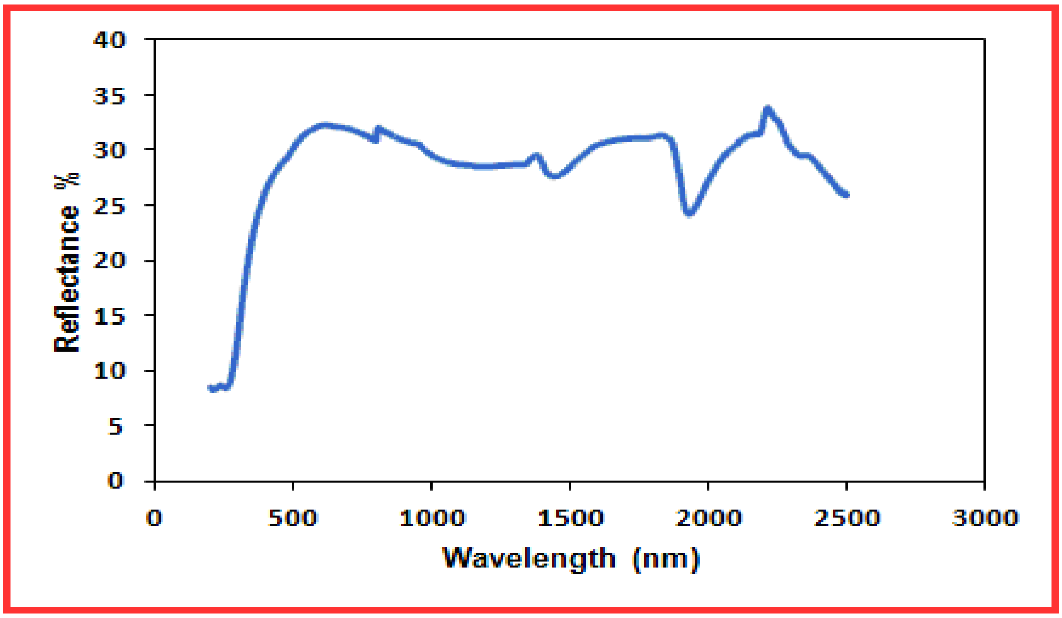


Fig. 5. UV/VIS/NIR reflectance spectra of Blank Asbestos sheet

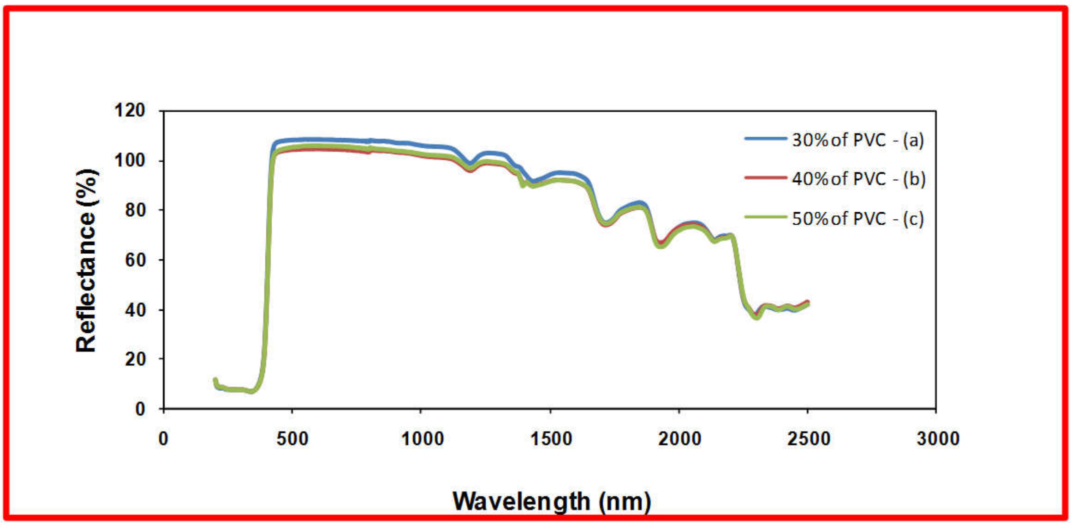


Fig. 6. UV/VIS/NIR reflectance spectra of (a) IR resistant coated Asbestos sheet (30% PVC) (b) IR resistant coated Asbestos sheet (40% PVC) (c) IR resistant coated Asbestos sheet (50% PVC)

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

UV, VIS and NIR reflectance

The IR resistant coated paint reflectance is measured by using UV/VIS/NIR spectrometer (carry 5000: version=1.12) in fig.4 From the above fig.5 & fig.6 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. After coating the asbestos surface with 30% PVC a buoyant raise of 100% of reflectance is observed in the UV region and it is maintained in the near IR region up to 1400nm, it continued with a trivial change in reflectance and shows 95% of reflectance. When coating the asbestos surface with 40% PVC an optimistic raise of 100% of reflectance is observed in the UV region and it is maintained in the near IR region up to 1400nm, it continued with a trivial change in reflectance and illustrates 90% of reflectance. When coating the asbestos surface with 50% PVC a intrude raise of 100% of reflectance is observed in the UV region and it is maintained in the near IR region up to 1400nm, it continued with a trivial change in reflectance and illustrate 90%. The acrylic resin blended with chlorofluorocarbon produced good reflectance compared to single pigment TiO_2 (Coser *et al.,* 2015).

Conclusion

In this paper, we prepared a new IR resistant paint coated on asbestos sheet and characterized. In future, Water-based fluorocarbon coatings recommend new advantages and opportunities in both residential and commercial applications. IR resist inorganic pigment blending with acrylic resin reduces the building fatigue by reducing expansion and contraction due to heating and cooling cycles. 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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