

## **Development of Emulsion Paint from Trimethylol Urea/Polystyrene waste Copolymer Resin.**

S.A Osemeahon and B.J Dimas

*Modibbo Adama University of Technology, Yola, Nigeria*

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**Abstract:** Urea formaldehyde that is trimethylol urea (TMU) was synthesized and copolymerized with polystyrene waste (PS) to form TMU/PS copolymer binder for emulsion paint formulation. Formaldehyde emission and some physical properties of both TMU and TMU/PS were investigated. The resulting copolymer TMU/PS gave a better resin compared to pure TMU in terms of brittleness, low water resistance and formaldehyde emission. The emulsion paint formulated from both TMU and TMU/PS passed pH, viscosity, flexibility, opacity, gloss and storage stability tests. Paint from pure TMU failed adhesion, hardness, tackiness, resistance to blistering and drying time tests while that of TMU/PS paint recorded a pass in all the tests. Both paints were unaffected by the salt medium but surface defect were observed in the case of TMU films in alkali and acid solutions. TMU/PS films were unaffected by both the acid and alkali solutions. This study provides a potential route for both VOC reduction in coating surfaces and environmental pollution from waste polystyrene disposal.

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### **I. Introduction**

Oil-based paints display a lot of advantages such as water resistance, durability and flexibility over water borne paints. However, due to its use of volatile organic solvent (VOC) as solvent and consequent of environmental pollution, the taste for oil-based paint is fast diminishing in many countries all over the world. For the purpose of both environmental and human survival, VOC reduction from coating surfaces is a task that must be done. VOCs are harmful materials to the environment, as they are partly responsible for air pollution, depletion of ozone layer, global warming and health risk to all living organisms [1, 2].

Water borne paint are used in protection and decoration of most building nowadays because of their ease of applications, fast drying, non-odour, good-wash ability and excellent finish. However, water borne paints are limited in application due to the relatively low quality when compared to oil-based coatings. Although researches [3, 4, 5], have been directed towards eco-friendly water-thinnable paints, the dream of obtaining an emulsion paint with satisfactory service properties as compared to solvent based system has not been achieved [6].

Urea formaldehyde resins are extremely tough, scratch resistant polymers which are used for a host of domestic and industrial applications. Some advantages of urea formaldehyde resin includes low price, good technological properties, absence of colors in cured polymer and easiness of application (7, 8]. However, the structure of the thermosetting resin also leads to unwanted properties that restrict their application. Urea formaldehyde resin is too hard and brittle to be used alone as coating material. Urea formaldehyde resin also exhibit poor water resistance and formaldehyde emission hence creating problems of environmental pollution and inconsistency in the quality of product with age. Since Urea formaldehyde resin is soluble in water, it full utilization is needed to meet different requirements of the coating industry in terms of emulsion paint formulation and consequent reduction in VOC in our environment. This is only achievable if the inherent problems of brittleness, poor water resistance and formaldehyde emission associated with urea formaldehyde resin are taken care of [9, 10].

Polystyrene is an important polymer of immense use industrially as it is highly resistance to shock, chemicals and weather conditions. It dissolves in many solvents and has a lot of uses as plastic in industry for domestic purposes [11]. The expanded polystyrene is used extensively due to its cost effectiveness. Although PS has immense usage industrially, most of products end up as municipal solid waste, thereby constituting environmental nuisance. Since the products are not biodegradable, once used and discarded, they become a major waste management challenge resulting into green house emission and ecological damage [12, 13], So disposing polystyrene waste in landfills is not a sustainable practice, and hence, recycling polystyrene becomes a needed alternative [14].

An up-cycling of the post consumer blend wastes for value-added goals remains a challenge for the scientific community [15]. In a recent work, Poly(ethylene) terephthalate (PET) which leads to polymer wastes were recycled and utilized for coating application and the paint showed excellent gloss, flexibility, pencil hardness, adhesion, no cracks and good resistance to acids[16]. Polyester Polyol was Derived from Waste Poly (Ethylene Terephthalate) and used for Coating Application on Mild Steel [17]. Polyethylene waste was used to

modified urea formaldehyde and used as binder for emulsion paint formulation [18]. In this work, TMU was synthesized and copolymerized with PS waste to form a copolymer binder for emulsion paint formulation with the aim of reducing VOCs and the removal of waste polystyrene from our environment.

## **II. Materials And Method**

### **Materials/reagents**

Urea, formaldehyde, sodium dihydrogen phosphate, sulphuric acid, sodium hydroxide, pellets, butanol, Ammonia and sucrose were reagent grade products from the British Drug House (BDH). Titanium dioxide, calcium carbonate, sodium carbonate, kaolin, aluminium silicate, calgon, anti-skining agent, nicofoam, genepour, drier, bermocoll, troystan, dispersant, water, gasoline were obtained from yola market Nigeria. All materials were used as received. Polystyrene waste was collected from refuse dumps around Yola, Nigeria.

### **Methods**

The methods used for the resin synthesis and determination of the film properties were according To: [18].

#### **Resin synthesis**

Trimethylol urea (TMU) was prepared by using one mole (6.0 g) of urea to react with three moles (24.3 ml) of 37% (w/v) formaldehyde using 0.2g of sodium dihydrogen phosphate as catalyst. The pH of the solution was adjusted to 6 by using 0.5M  $H_2SO_4$  and 1.0M NaOH solutions. The solution was heated in a thermostatically controlled water bath at 70°C. The reaction was allowed to proceed for 2 h after which the sample was removed and kept at room temperature (30°C).

#### **Formation of liquid PS**

Solid PS was constituted into liquid form by dissolving 5g of PS waste in 25ml of gasoline. The mixture was stirred continuously and allowed to stay for 24h to achieve a homogenous solution.

#### **Preparation of TMU/PS blends and films**

Blend of TMU and PS was prepared by adding varying amount of PS (0-70%) in TMU resin. The mixture was stirred and left for 24 h at room temperature (30°C) and then poured into a glass Petri dish for casting. The resin was allowed to cure and set for seven days at (30°C). The physical properties of the resin films were investigated.

#### **Determination of viscosity and gel time**

A 100 ml Phywe made graduated glass macro-syringe was utilized for the measurement. The apparatus was standardized with 20% (W/V) sucrose solution whose viscosity is 2.0 mPa.s at 30°C. The viscosity of the resin was evaluated in relation to that of the standard sucrose solution at 30°C. Five different readings were taken for each sample and the average value calculated. The gel point of the resin was determined by monitoring the viscosity of the resin with time until a constant viscosity profile was obtained.

#### **Determination of density, turbidity, melting point and refractive index**

The density of the resin was determined by taking the weight of a known volume of resin inside a density bottle using metler (Model, AT400) weighing balance. Five readings were taken for each sample and average value calculated. The turbidity of the resin samples was determined by using Hanna microprocessor turbidity meter (Model, H193703). The melting points of the film samples were determined by using Galenkamp melting point apparatus (Model, MFB600-010F). The refractive indices of the resin samples were determined with Abbe refractometer. The above properties were determined according to standard method [19].

#### **Determination of moisture uptake**

The moisture uptakes of the resin films were determined gravimetrically. Known weight of the sample was introduced into desiccators containing a saturated solution of sodium chloride. The increase in weight (wet weight) of the sample was monitored until a constant weight is obtained. The difference between the wet weight and dry weight of the sample was then recorded as the moisture uptake by resin. Triplicate determinations were made for the sample and the average value recorded.

#### **Determination of formaldehyde emission**

Formaldehyde emission test was performed by using the standard 2 h desiccator test. The mold used was made from aluminium foil with a dimension of 69.6 x 126.5 mm and thickness of 12.0 mm. The emitted formaldehyde was absorbed in 25.0 ml of water and analyzed by a refractometri technique using Abbe refractometer. Triplicate determinations were made for the samples and the average value taken.

**Elongation at break**

The elongation at break was measured using Inston Tensile Testing Machine (Model 1026). Resin films of dimension 50 mm long, 10 mm wide and 0.15 mm thick was brought to rupture at a clamp rate of 20 mm/min and a full load of 20kg. A number of five runs were carried out for each sample and the average elongation evaluated and expressed as the percentage increase in length.

**Water solubility**

The solubility of the TMU/PS blend in water was obtained by mixing 1ml of the resin with 5ml of distilled water at room temperature (30<sup>o</sup>C).

**Paint formulation**

The method described by [6]; was adopted for the paint formulation. Paint production process involves three main stages:

**First Stage**

At the first stage, additives such as, dispersants, defoamer, thickener, anti-skin, drier, wetting agents, stabilizer, pH adjuster and preservatives were added. The basic purpose of this stage is to provide a favourable environment for wetting and dispersion of particles. A volume of 185 ml of distilled water was introduced into a litter mixing tank and the overhead stirrer switched on after the addition of 12.7g of the additives as shown in Table 1. This mixture was stirred using a high speed stirrer for 15minutes.

**Second Stage**

In the second stage, also known as “Millbase”, pigments and extenders were dispersed in the mills. Immediately after dispersion, the stirrer speed in the millbase stage was increased to a very high speed and the mixture was stirred for another 15minutes. In millbase, binder was not added to avoid its structural deformation under the high mechanical forces.

**Third Stage**

Finally, binder plus the rest of the additives used in the first stage were mixed with 15ml of water . This stage is called “Letdown”. In this stage, the mixture was stirred at moderate speed for another 15 minutes. Energy losses in the mill base are minimized by adding thickeners before the dispersion stage of the production process. The above processes was repeated using pure TMU as binder. The details of the formulations are in Table 1.

**Table 1:** Recipe for the formulation of emulsion paints from TMU/PS binders.

Stage	Materials	Quantity in g
First	Water	185
	Anti-foam	0.2
	Drier	0.2
	Calgon	1.16
	Genepour	1.16
	Bermocoll	2.5
	Troystan	1.14
	Dispersant	0.2
	Butanol	5
	Ammonia	0.54
Millbase	TiO <sub>2</sub>	50
	Al <sub>2</sub> (SiO) <sub>3</sub>	11.2
	Na <sub>2</sub> CO <sub>3</sub>	0.58
	Kaolin	2.52
	CaCO <sub>3</sub>	123.0
Letdown	Binder	100
	Water	15
	Dispersant	0.2
	Nicofoam	0.2
	Anti-skining agent	0.2
<b>Total</b>		<b>500g</b>







