

Flame Retardant Polyurethane Corrosion Protective Coating

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ABSTRACT

External corrosion of metal structures is very common. Flame incidents are also common in the industry. Different types of organic coatings are used to delay the corrosion process as well as to act as a flame-retardant material around the world. It is challenging to use one coating for both purposes. To fulfill this demand a series of water borne polyurethane (PU) coating materials were synthesized in this study. Melamine (M) and modified melamine (MM) were used to synthesize the PU dispersion. The coating nature was changed from hydrophilic to hydrophobic by using M and MM. The coating adhesive strength was also increased with the addition of M and MM. A significant level of improvement was also recorded in corrosion protection and flame-retardant properties. The coating protective performance was higher for MM compared to those for M with fixed compositions.

Key words: Polyurethane, corrosion, flame

INTRODUCTION

Metal and its structures corrosion is a natural process. The process started and accelerated in the presence of electrolytes [1, 2]. Thus, it's highly encouraged to stop this electrolyte passage. One of the ways to resist the passage of electrolytes is by making a barrier. The most popular method of such a barrier is an organic coating which mainly comes from polymer resin along with pigments, and additives. Different organic coatings are being used to make a barrier that can ultimately protect the metals and their structures. Epoxy, polyurethane (PU), and acrylate coatings are widely being used for this purpose [3-7].

Flame incidents are also common everywhere. Unfortunately, it's not taken very seriously as it is a sudden action. But this incident can damage not only the property but also human life. The common trend is taking action after the flame incident. Recently, people are encouraged to take action before the incident. Thus, different techniques are being considered to save the structures from the flame incident. Applying a flame-retardant coating is one of the useful methods to limit the damage. Different organic coatings showed a promising flame-retardant property. Especially epoxy, acrylate, and PU coatings have been considered by many research groups for this purpose [2].

A tricky scenario appears when a structure is prepared for possible encounters for both corrosion and flame. Usually, a base polymer resin possesses a certain level of corrosion and flame protection which is not enough to save from the incident. Thus, protection enhancement is required. Different functional group attachment in base polymer to enhance the flame-retardant property is a widely practiced method. Unfortunately, many flame-retardant groups are corrosive [8]. Therefore, it's challenging to enhance both protective properties.

Heterocyclic compounds possess various properties [9, 10]. By using a proper content, the heterocyclic compound can increase barrier resistance, adhesive strength, and mechanical properties. At the same time, it can enhance anti-corrosion and flame-retardant properties. Melamine and its derivatives, as heterocyclic compounds, can increase the mentioned properties. The challenges appear in polymer dispersion stability as well as the proper content. In this study, we used melamine (M) and hexamethoxymethylmelamine (HMMM) as modified melamine in waterborne polyurethane (WBPU) coating to improve both anti-corrosion and flame-retardant properties. WBPU is an environmentally friendly material as it mainly contains water as a solvent [1-3]. In the last two decades, the WBPU properties also improved by finding proper monomers and their contents.

Table 1: Formulation of coating

Coating	Composition (Mol)					Melamine (wt%)	Modified Melamine (wt%)
	Polyol	Hydrophilic agent	Neutralizer	Chain extender	Isocyanate		
WBPU	0.615	1.025	1.025	0.350	2.000	...	..
WBPU/M-1	0.615	1.025	1.025	0.350	2.000	0.50	..
WBPU/M-2	0.615	1.025	1.025	0.350	2.000	1.00	..
WBPU/M-3	0.615	1.025	1.025	0.350	2.000	1.50	..
WBPU/M-4	0.615	1.025	1.025	0.350	2.000	2.00	..
WBPU/MM-1	0.615	1.025	1.025	0.350	2.000	..	0.50
WBPU/MM-2	0.615	1.025	1.025	0.350	2.000	..	1.00
WBPU/MM-3	0.615	1.025	1.025	0.350	2.000	..	1.50
WBPU/MM-4	0.615	1.025	1.025	0.350	2.000	..	2.00

Polyol = Poly (tetramethyleneoxide glycol, number-average molecular weight = 2000 g/mol)

Hydrophilic agent = 2, 2- dimethylol propionic acid (DMPA)

Neutralizer = Triethylamine (TEA), Chain extender = Eethylene diamine (EDA)

Diisocyanate = 4,4-dicyclohexylmethane diisocyanate (H_{12} MDI),

EXPERIMENTAL PROCEDURE

Preparation of WBPU dispersion

The pristine WBPU dispersion was prepared by the pre-polymer process. The compositions of coatings are summarized in Table 1. The pre-polymers were prepared by charging polyol, isocyanate, and DPMA. Later, the neutralization, dispersion, and chain extension were completed. The detailed preparation process can be found in our previous reports [1, 3, 6].

WBPU/M and WBPU/MM dispersion preparation

The WBPU/M and WBPU/MM dispersions were prepared following the same procedure. The M and MM were mixed in pre-polymer before the neutralization step. The *p*-toluene sulphonic acid (0.05 wt%) is also added to the mixture as a catalyst.

Preparation of the film

A defined amount of 10 g dispersion was used to prepare the film. The respective dispersion was poured onto a round Teflon disc and settled for a few bubbles. Later, the dispersion was dried for 48