Synthesis and Charcterization of UV-curable Polyurethane Acrylates Coating Composition for PVC Tiles

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PVC 바닥상재용 광경화형 폴리우레탄 아크릴 수지의 합성 및 특성고찰

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요 약

Application of UV curing technique for poly vinyl chloride (PVC) floor tiles coating has improved the quality of PVC floor. Various formulations including acrylated oligomers based on a polyurethane were blended with reactive monomers, photoinitiators and other additives. The used oligomers are commercial aliphatic urethane acrylates. Thin films were prepared on PVC tiles by bar coating with different formulations using UV radiation. The coating resins were characterized by FTIR. The properties of UV-cured films such as gloss grade and adhesion were examined. The properties of UV-cured films dependent on the influence of composition and processing conditions was studied. The investigation was conducted to achieve an optimal domain of composition and desired coating effect.

1. Introduction

UV radiation curing has become a well-accepted technology which has found a large number of applications in various industrial areas such as inks, adhesive and coatings. [1] UV radiation curing involves the polymerization and cross-linking of functional monomers and oligomers (usually liquid) into a cross-linked polymer network (usually a solid film) induced by photons. [2] UV-curable formulations usually contain three basic components: photoinitiators, functionalized oligomers and monomers. [1] The great reactivity of acrylate monomers, together with the large choice of acrylate-functionalised oligomers, have afforded these radical-systems a leading position in UV-curing applications. [3] Among the commercially acrylated oligomers, the polyurethane acrylate is to combine the high performance and many possible applications of polyurethane coating systems with the curing rate and efficiency of photopolymerization. [4] To comply with the needs of coatings and curing processes and to achieve the desired protective effects, the formulation of UV-curable coatings requires considerable skill in balancing a number of competing properties such as flexibility, adhesion, toughness, abrasion resistance, resistance to discoloration, chemical and stain resistance, as well as cure rate. [5] The acrylated polyurethanes are recommended for abrasion resistance for PVC floor tiles.

2. Experimental

2.1. Materials

The UV curable polyurethane acylate system was made up of three main components: firstly, aliphatic polyurethane acylate oligomer secondly, reactive monomer and thirdly, the photoinitiators

used to obtain the UV curable coatings. The reactive diluent monomers was poly(ethylene glycol) diacylate, 2-HPA and 2-PEA .

A series of two UV curing coating compositions were prepared by mixing to a uniform consistency components listed in Table 1.

[Table 1] Formulations of coating resins

components	Compositions (wt.%)	
	Non-glossy	Half-glossy
monomers	49.1	50.0
oligomers	17.7	29.4
Additives	5.0	3.9
diluents	24.7	12.6
photoinitiator	3.5	4.1
Total	100	100

2.2. Application

In order to investigate the performance of the cured film, each UV curable coating was coated onto PVC tile using a bar coater (No. 7) and cured in a conveyer belt type UV curing system LZ-UH101RCH (Lichtzen Korea) equipped with a high-pressure mercury lamp (main wavelength: 365nm).

2.3. Laboratory tests

2.3.1 Viscosity

The viscosity of the samples was measured with a Rion viscotester (VT-03F) at 298K.

[Table 2] Viscosity of the coating formulations

	Viscosity (298K)
Half-glossy	180 cP
Non-glossy	140 cP

2.3.2 Fourier transformation of infrared spectroscopy (FT-IR)

The IR spectra of the UV curing formulations were characterized before coating using a KBr disc.

2.3.3 Gloss measurements

The gloss grade of cured film was determined at 60° using a Tri-Microgloss 20-60-85 (Sheen Instruments LTD).

2.3.4 Adhesion measurements

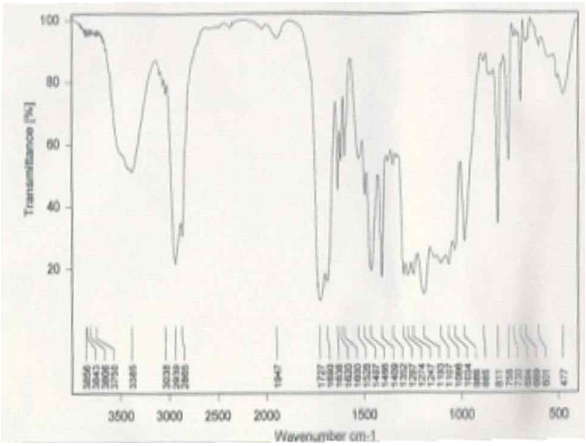
The adhesion measurements were carried out using the tape test method according to ASTM D 3359 standard specification. [6]

3. Results and Discussion

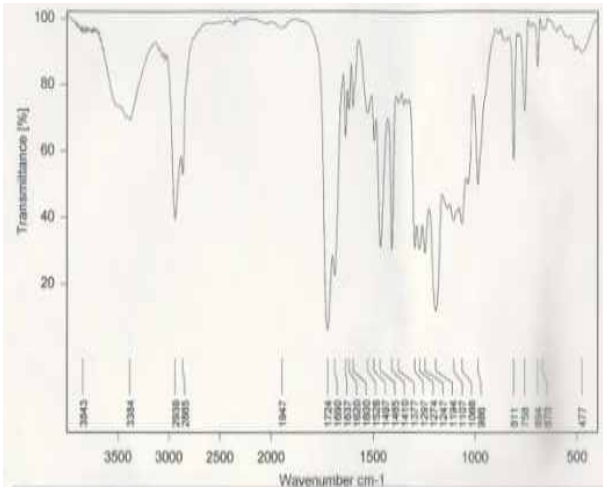
3.1. Functional group analysis of resins

Because polyurethane acrylate oligomer has features of high reactivity and fine mechanical properties, we used the reactive polyurethane acrylate oligomers as coating agents. Fourier transform infrared spectroscopy is well established as an analytical technique for functional group analysis. The structure of the formulations were characterized by FTIR. FTIR spectra was taken within the scanning range of 400-4,000 nm for 32 times at room temperature.

Figure 1 shows the FTIR spectrum of non-glossy formulations. In urethane oligomers, the absorption of -NH- at 3385 cm^{-1}, -CN- at 1528 $cm^{-1}$and -COO at 1727 cm^{-1}revealed the formation of urethane group. The absorption of -C=C- was at 1409 $cm^{-1}$and 811cm^{-1}.Therefore, the structure of oligomer could be confirmed. Figure 2 shows the FTIR spectrum of half-glossy compositions. Compared with non-glossy binder, the frequencies of functional groups were very similar. Although the intensity of main functional groups was different in some degree, the adhesions of the two kinds of binders were same.



[Figure 1] FTIR spectroscopyof non-glossy coating formulations.



[Figure 2] FTIR spectroscopy of half-glossy coating formulations.

3.2. General performance of coatings

Adhesion is considered to be of major importance when formulating surface coatings. PVC tiles can be coated when the surface tension of the formulation is lower than that of the substrate. The surface tension strongly depends on the polarity of the binders, which is essentially determined by the type and number of the functional groups. Polar groups, such as hydroxy or carboxy groups, increase the surface tension.

As the major components in UV-curing systems, monomers and oligomers can be selected on the basis of their effects on adhesion at first. In this paper the adhesion of the cured coatings showed that the formulation of non-glossy and half-glossy coating both achieved good performace to PVC substrates.

[Table 3] Assignments of the peaks of FTIR spectrum for non-glossy resin

Wave number (cm^{-1})	Assignment
3385	Stretching vibration of the urethane NH bond
28652939	Stretching vibration of the aliphatic CH bond
1690-1727	Amide I, stretching vibration of the C=O bond
1600	Stretching vibration of the benzene CC
1528	Amide II, stretching vibration of the benzene ring
1466	Bending vibration of the aliphatic CH bond [7]
1409	Stretching vibration of CC in $RCH=CH_2$
	Stretching vibration of the benzene CC
1247	Amide III, antisymmetric stretching vibration of COOC
1107	Symmetric stretching vibration of COOC [8]
1066	Symmetric stretching vibration of COOC
811	Out-of-plane bending of CH in $RCH=CH_2$
	Out-of-plane bending of CH in benzene ring

[Table 4] Adhesion and gloss of UV-cured non-glossy coatings on PVC tiles

Adhesion	5B	5B	5B
Gloss 60°	10.9	11.0	10.5

[Table 5] Adhesion and gloss of UV-cured half-glossy coatings on PVC tiles

Adhesion	5B	5B	5B
Gloss 60°	44.7	49.1	47.3

4. Conclusions

Adhesion is an important property for UV curable coating on PVC tiles since most other tests would assume that good adhesion between the coating and substrate exists. The choice of

oligomers and monomers is governed by the end use requirements. The application performance of the coatings is to aim for a balance of a good adhesion and required gloss. The urethane acrylate gave the best adhesion and this can broaden the application of UV coatings further on PVC floor industry.

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