DEVELOPMENT OF NANOCOMPOSITE COATINGS BY RADIATION CURING

N.G. Nik Salleh, M.S. Alias, M.Z. Salleh, N.H. Mudri, M.H. Harun & K.A. Abdul Halim.

Nik_Ghazali@nuclearmalaysia.gov.my
Malaysian Nuclear Agency

Poster Number (ID):
PA2-34 (172)

ICARST 2017
International Conference on Applications of Radiation Science and Technology
24 - 28 April 2017
Vienna, Austria

ABSTRACT

Radiation curing is one of the most effective processes to produce rapidly composite materials at ambient temperature. Silica nanoparticles can be introduced into radiation curable resins to produce scratch and abrasion resistant materials, which can be used as coating materials. In preparation of radiation cured polymeric composites for wood based products, we synthesized radiation curable silico-organic nanoparticles from silica/acrylates system. These nano-sized silica particles were used as fillers. Epoxy acrylate was used as prepolymer while pentaerythritol triacrylate and tetraacrylate (PETIA) was used as monomer. The surface of the silica was chemically modified to improve the embedding of the filler within the acrylate matrix. Modification of the silica surface was done to overcome the problem of incompatibility with acrylates at high silica contents. The nature of the nanoparticles changed from hydrophilic to organophilic. These polymerization active nanoparticles were obtained by heterogeneous hydrolytic condensation of the silane to the silanol groups of the silica particles. Formulations useful for technical coating processes could be prepared and cured by electron beam (EB) or ultraviolet (UV) light. These composite materials showed highly improved mechanical properties and provided a high network density whilst the coatings remain transparent. These polymeric nanocomposites show excellent resistances toward scratch and abrasion properties compared to pure acrylates.

INTRODUCTION

Kencana Fibercomposite is a manufacturer producing high performance fiber composites derived from a revolutionary green technology. These composites are alternative to wood and used in building construction. However, they are vulnerable to scratch and abrasion during handling and transportation. Therefore, Kencana Fibercomposite and Nuclear Malaysia have collaborated to develop scratch and abrasion resistant nanocomposite coatings. The most appropriate process to cure the materials is using radiation curing technology. The technology offers several advantages such as high speed fast cure, improve productivity and product performance, curing at room temperature, energy efficient and elimination of volatile organic compound (VOC).

OBJECTIVE

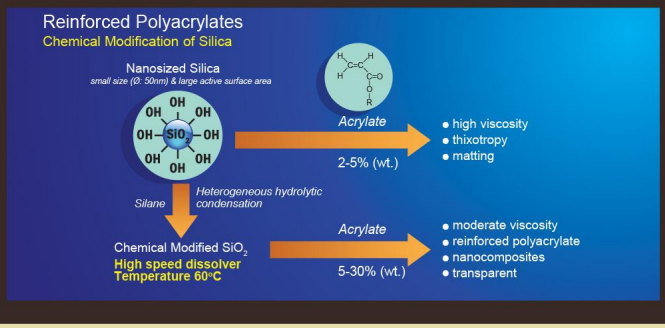
To develop and produce highly scratch and abrasion resistant coating materials by radiation curing

METHODOLOGY

Preparation of silico-organic nanoparticles was carried out in a reactor. Maleic anhydride, dissolved in water, was introduced in a mixture of several acrylates and 4-methoxyphenol. The coupling agent such as VTMOS was added within 30 minutes. Finally, nano-sized silica particles were dispersed under intensive stirring during 1-2 hours using a high speed dissolver at 60ºC. The coating materials were cured using electron beam (EB) or ultraviolet (UV) light and characterized by several methods such as scratch test and Taber abrasion test.

Formulations	Materials (%)			
	PETIA	VTMOS	SiO_2	EB600
SF-1	30	25	–	45
SF-2	30	25	10	35
SF-3	30	25	20	25
SF-4	30	25	30	15

Table 1 Percentage of materials in the formulations



RESULTS

Formulations	Gel Content (%)	Pendulum Hardness (%)	
		EB	UV
SF-1	96.4	74.0	70.1
SF-2	97.3	73.7	73.6
SF-3	98.3	73.1	73.7
SF-4	98.6	65.1	72.9

Table 2 Gel content and pendulum hardness measurement

Formulations	Weight Loss (mg)	
	EB	UV
SF-1	44.1	44.4
SF-2	22.0	19.9
SF-3	13.2	12.0
SF-4	8.5	6.7

Table 3 Abrasion resistant properties

Formulations	Resistant to scratch (N)	
	EB	UV
SF-1	0.9	0.7
SF-2	1.5	1.0
SF-3	3.5	2.0
SF-4	4.5	2.5

Table 4 Scratch resistant properties (steel ball tip)

Formulations	Resistant to scratch (N)	
	EB	UV
SF-1	9	>10
SF-2	>10	>10
SF-3	>10	>10
SF-4	>10	>10

Table 5 Scratch resistant properties (diamond tip)

CONCLUSION

The nanocomposite coating materials showed highly improved mechanical properties and excellent resistances toward scratch and abrasion properties when compared to pure materials without nanoparticles.