Environment-friendly Hwangtoh composites using water soluble resin for interior materials

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Abstract
The objective of this research was to develop environment-friendly Hwangtoh binder for application of Hwangtoh for interior wall finishing materials in the housing. To mix with Hwangtoh powder, water soluble MPU resin with EVA, PVA, CaCO3 and inorganic fillers were designed. Far infrared ray irradiation, TVOC emission behavior, surface bonding strength and surface crack behavior were studied by comparing to epoxy/Hwangtoh blend as control. To utilize the advantage of Hwangtoh such as high absorbency, self-purification, deodorizing, sanitizing properties and radiation of far infrared rays in the filed of modern housing, this study was the foundation to develop environment-friendly binder for Hwangtoh.

Keywords: Environment-friendly, Hwangtoh, Finishing materials, TVOC, Far infrared rays

Introduction

Sick house syndrome is a serious problem with the air quality caused by indoor contaminants in the home and work place [1,2]. Public interest in healthy housing with eco-friendly materials has sharply increased recently. There has been growing concern regarding healthy housing using environment-friendly materials. Hwangtoh is one of the representative healthy and environment-friendly materials with the properties of high absorbency, self-purification, deodorizing and sanitizing properties [2,3].

This paper presents the developed Hwangtoh wall finishing materials with environmental-friendly water soluble resin which have good characteristics such as far-red frequency irradiation, low VOCs emission, good bonding property and habitat without surface crack.

Materials

To blend water soluble MPU adhesive, EVA(ethylene-vinyl acetate copolymer) emulsion was used from Air Product, Korea. 70 parts of EVA and 20 parts of PVA was blended. Commercial PVA from DC chemical(Seoul, Korea) was used. The blend was mixed by mechanical stirring for 10 min. 50 parts of $CaCO_3$ was added to blend. As additives 10 parts of silica and a part of carboxyl acid was added. After anti forming agent was added, water was added to control solid content was 50%.. This MPU was used as base resin. 10wt% of isocyanate-based compound was used as curing agent. Finally, Hwangtoh wall finishing materials were blended as shown Table 1. Inorganic additive was compound of $CaCo_3$, clay and silica. To compare with these water soluble resin, epoxy resin and hwangtoh blend was used as control.

Methods

A rack was constructed with the top and two sides containing FIR sources. The FIR sources were constructed from a ceramic-coated sheet of aluminum, and the opposite side of the sheet was heated by an electric heater. FIR emitted from the ceramic-coated sheet ranged from 5 to 25 μm with a maximal intensity of 8 to 12 μm. The temperature in the rack was approximately 40℃. These temperatures were continuously monitored with a sensor placed in the rack. These equipments were supplied by Sagano Co. Ltd (Kobe, Japan). Irradiation rate and irradiation energy at 40 ℃ were detected.

The 20 L small chamber was supplied with purified and humidified air at a ventilation rate of 0.5ACH through an air-flow of 0.01m3•h-1. In this paper, TVOC was defined by conversion of all areas of the peaks between C_6 and C_{16} to concentrations using the toluene response factor. Any peak area under ten was defined as the limit of detection. The gas was sampled by absorption on Tenax-TA, 7 days after the sample specimens were installed into the 20L small chamber, according to the regulation from the Ministry of the Environment, Korea.

The bonding strength between the Hwangtoh wall finishing blends and concrete panel was tested with a Universal Testing Machine (UTM, Hounds Co.) in the tensile mode. On the concrete panel (100mm × 200mm), Hwangtoh wall finishing blends and Hwangtoh/epoxy were spread as thickness of 5mm. These samples were dried at room temperature for 24 hours. The crack on the surface was checked.

Results

FIR has several benefits for human body; it 1)stimulates enzyme activity and metabolism, 2) promotes the killing of many pathogenic (disease causing) bacteria, viruses, fungi and parasites, 3)relieves nervous tension and relax autoneuro muscles 4)promotes rebuilding of injured tissue and 5)strengthens the Immune System [4,5]. FIR irradiation of Hwangtoh wall finishing materials blends are shown in Table 2. Hwangtoh with MPU resins shows higher Irradiation rate at 5~20um than Epoxy/Hwangtoh blend. Hwangtoh is one of good ceramic materials which emits high far infrared ray. Although epoxy, chemical binder, interrupted irradiation of far infrared ray, MPU binders showed higher irradiation rate dew to water soluble binder contain much lower percentage of chemical compound than only chemical binder. In the case of irradiation energy, MPU-B and MPU-C was higher than Epoxy/Hwangtoh blend. From these results, water contain rate in Hwangtoh finishing materials leads far infrared rays irradiation from Hwangtoh ceramic.

In Figure 1, TVOC emission from Epoxy/Hwangtoh blend and MPU/Hwangtoh blends by 20L chamber method is shown. TVOC emission results from MPU/Hwangtoh blends were too low to be concerned about indoor air pollution. In Korea, the Ministry of Environment provides guidelines of formaldehyde and VOC emissions from building materials. Because a gypsum board is used as interior material for construction of buildings and houses, the emission of indoor air pollution materials such as formaldehyde is important. However, there was much lower formaldehyde emission and TVOC emission factor was under the 'Excellent' grade as defined by KACA [6,7]. Epoxy resin is one of major synthetic resins manufactured in the world. It emits VOCs during the production and use. Because epoxy resin emits VOCs, Epoxy/Hwangtoh blend shows higher TVOC emission result than MPU/Hwangtoh blends. As interior building materials, the MPU/Hwangtoh blends can be used without indoor air pollution problems because there is water soluble resin. From these results, MPU/Hwangtoh blends should be considered for wall finishing materials for interior because water soluble resins are the most practical approaches used to lower the emissions of VOC.

Because adhesion failure was appeared between the Hwangtoh wall finishing blends and concrete panel the surface bonding strength was well measured in this test. The results of the surface bonding properties are shown in Figure 2. Although the bonding strength of Epoxy/Hwangtoh blend showed highest among the samples, the bonding strength of water soluble MPU/Hwangtoh blends samples were increased as water contents were increased. Finally, the bonding strength of MPU-C/Hwangtoh blend reached to almost similar lever with epoxy/Hwangtoh blend. We found the reason of this result from the surface crack behavior.

As increasing water content in MPU/Hwangtoh blends, the surface crack was reduced and disappeared on surface of Hwangtoh finishing. Water made decreasing viscosity of MPU/Hwangtoh blend. Lower viscosity led vigorous mobility of Hwangtoh particle and resin. As interior wall finishing material, reduction of surface crack is important factor. With water contents, surface cracks of MPU/Hwangtoh blends could be controlled.

Conclusions

Water soluble MPU resins manufactured with EVA, PVA and CaCO3 were successfully applied to Hwangtoh for environment-friendly interior wall finishing materials. Irradiation rate and irradiation energy of far infrared ray of MPU/Hwangtoh blends were higher than those of epoxy/Hwangto blend as control. TVOC emission of MPU/Hwangtoh blend was satisfied the excellent grade of TVOC by Korea Air Clean Association. By the contents of water in the blend, the crack on cured surface of MPU/Hwangtoh blends was controlled. Reduction and disappearance of crack on cured surface led good bonding strength between MPU/Hwangtoh blend and concrete panel.

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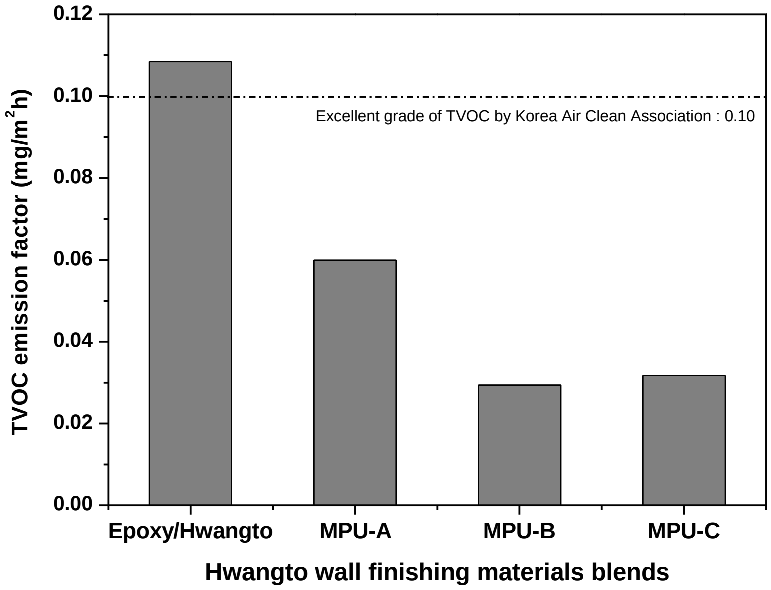

Fig. 1 TVOC emission of Hwangtoh wall finishing materials blends

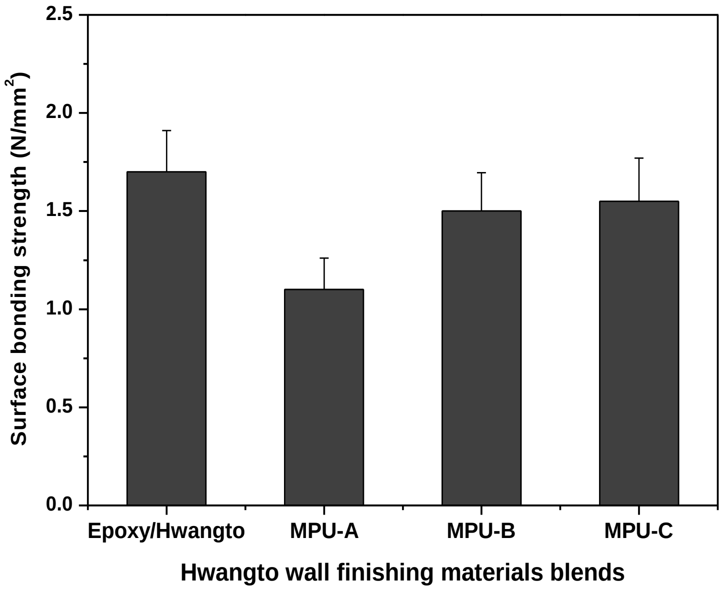

Fig. 2 Surface bonding strength of Hwangtoh wall finishing blends

Table 1 Hwangtoh wall finishing materials blending ratio (wt%)

	MPU	Isocyanate-based curing agent	Inorganic additive	Hwangto flour	Water
MPU -A	1	0.1	1	1	1.0
MPU -B	1	0.1	1	1	1.22
MPU -C	1	0.1	1	1	1.29

Table 2 Far infrared ray irradiation of Hwangtoh wall finishing materials blends

		Epoxy/Hwangto blend	MPU -A	MPU -B	MPU -C
Far infrared rays irradiation (at 40 ^{o}C)	Irradiation rate (at 5~20um)	0.895	0.992	0.990	0.991
	Irradiation energy (W/m^2)	3.70×10^2	3.70×10^2	3.72×10^2	3.71×10^2