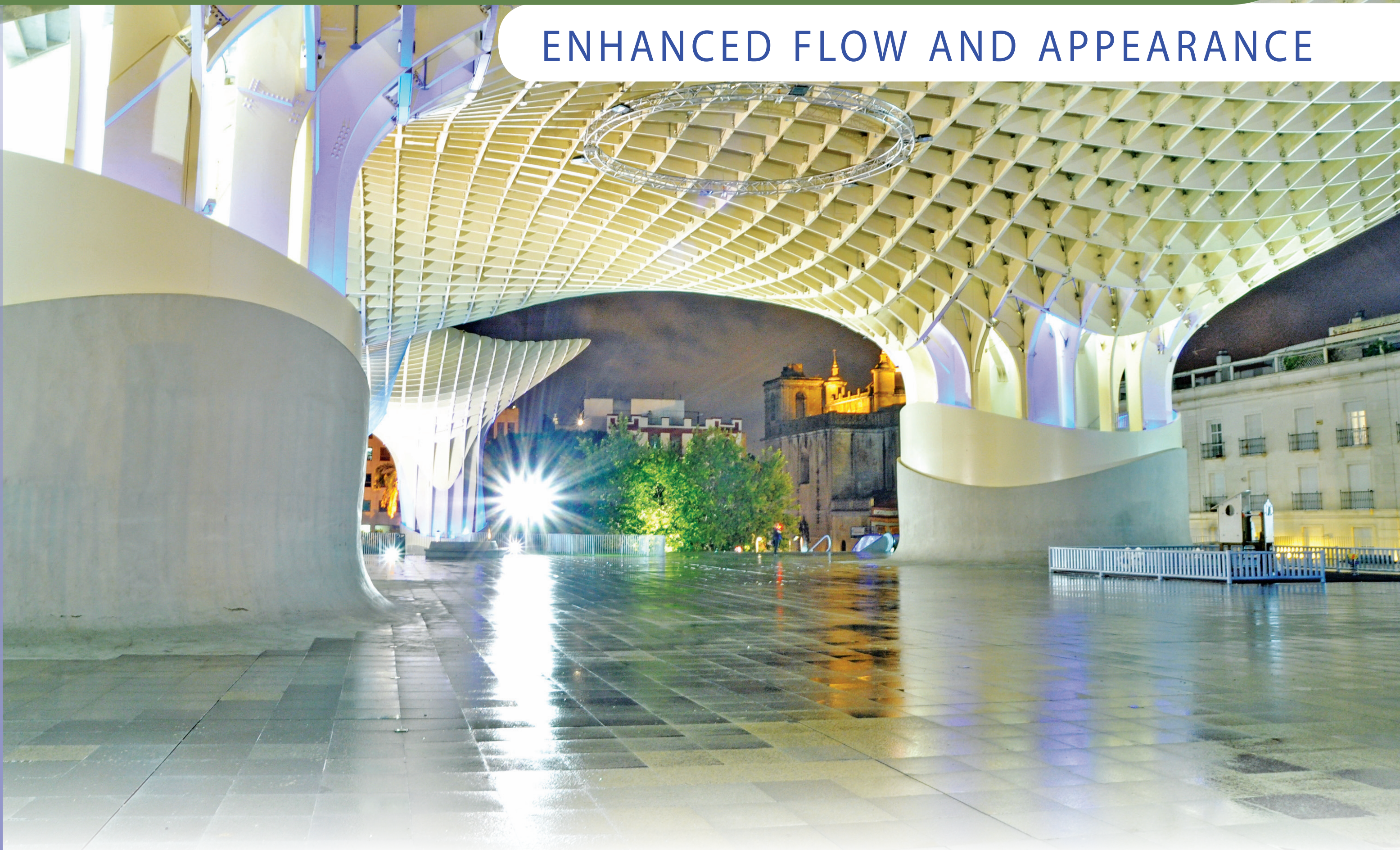
BIOBASED WATERBORNE FLOOR COATINGS WITH ENHANCED FLOW AND APPEARANCE



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The use of sustainable materials in the flooring market has gained widespread interest in recent years. Biobased raw materials contribute significantly to these efforts and are used to prepare environmentally friendly coatings. Castor oil-based emulsions are used as polyols in waterborne polyurethane coatings. These systems have outstanding chemical resistance and good durability. However, they have inherent issues like very short pot life and poor appearance and flow properties.

In this article, the development of a new castor oil-based polyol emulsion that can be used effectively in waterborne polyurethane applications is discussed. The modified polyol emulsion was formulated with polymeric MDI-based crosslinker, pigments, and additives to prepare thick concrete coatings. The appearance of the system, flow behavior, adhesion characteristics, surface roughness, and working life of the formulations were compared with the control.

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INTRODUCTION

Floors are primarily coated to increase the durability and life of the substrate and to enhance the aesthetics. Over the years, the types of coatings applied and their methods of application have evolved. Specifically, they have progressed to more refined chemistry and ease of application, and the industrial floor coatings are typically applied by contractors who are well trained in safety and application skills.[1,2] Further, these maintenance and protective floor coatings can be defined by the chemistry used. The predominant technology, epoxies, are proven for their adequate

Table 1—Polyol Emulsion Properties

Property	PE-1	PE-2
% NV by Weight	70.0	70.0
Brookfield viscosity, cPs	800–1000	600–800
Particle size, nm	~700	~700
pH	7.5	7.5
Hydroxyl %	2.7– 3.3	2.2–2.8

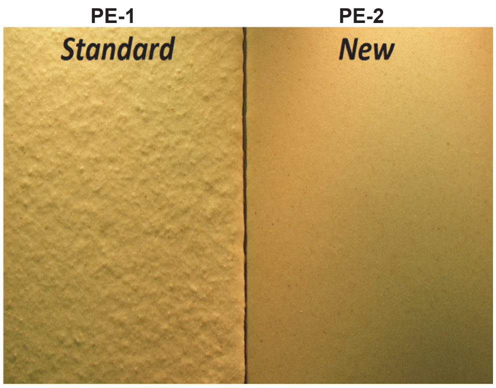


Figure 1—Flow/appearance photos for PE1 (standard) and PE2 (new) improved system.

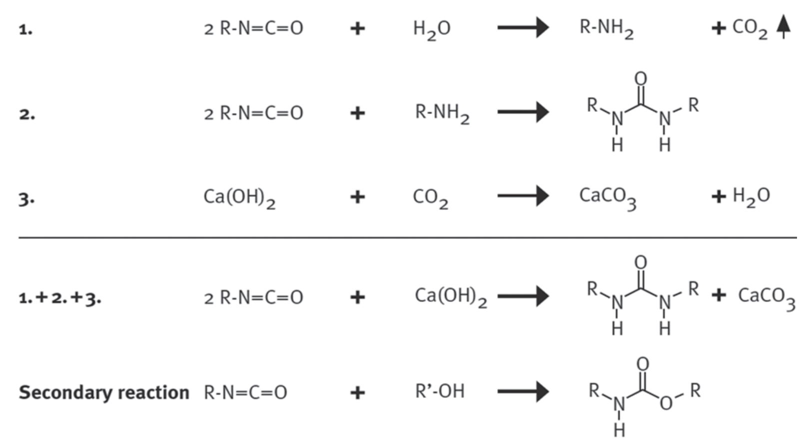
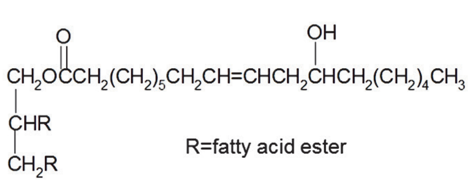


Figure 2—Crosslinking and other reactions.

performance combined with good economics. However, the standard epoxies have limitations, namely, limited low-temperature cure, long cure time, and low flexibility.

Polyurethane systems are used to overcome these limitations. The wide selection of polyols and polyisocyanates available for these two-component systems can help the formulator design and develop systems with a wide range of performance characteristics. Depending on the application areas, the systems can be aliphatic or aromatic. For outstanding outdoor durability, aliphatic systems are typically used, whereas for general areas, aromatic systems are preferred for their rapid cure and improved economics. The polyols most commonly used are hydroxyl functional polyethers and polyesters, while specialty applications include polycarbonates and other hybrid polyols. Most of these materials are based on petroleum derivatives, but there is a renewed interest in increasing the use of biobased products in this area.

Vegetable oil[3]-based polymers have been used in the polyurethane industry for years in the fields of foams, additives,[4] flow modifiers, lubricants, etc. These plant-based oils[5] are typically modified to introduce hydroxyl functional groups that can react with the polyisocyanate. However, the naturally available castor oil deserves special attention in that it already contains hydroxyl functionality and has a well-established usage in the polyurethane and coatings industry.[6] Castor oil is not used as a food source and it is chiefly composed of triglycerides of ricinoleic acid, with minor contributions from oleic, linoleic, and others.



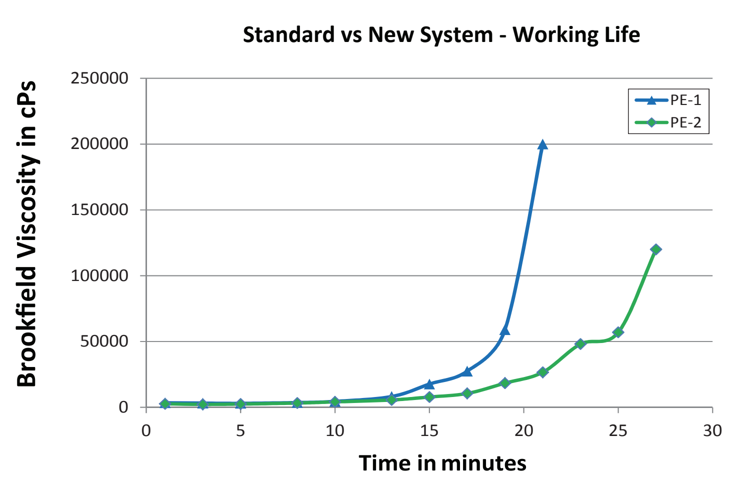


Figure 3—Viscosity vs time graph.

Table 2—Formulation for Three-Component Polymeric Concrete

Component	Parts by Weight
Add the two liquids below into a clean container	
Castor oil emulsion	18.3
Aromatic polyisocyanate	23.4
Blend components thoroughly with drill/paddle mixer for 2 min *Add pre-blended mortar portion below while mixing*	
White Portland cement	19.0
Hydrated lime	5.9
30–60 mesh (250–600 micron) silica sand	33.1
Mineral oil	0.3
Total	100.0

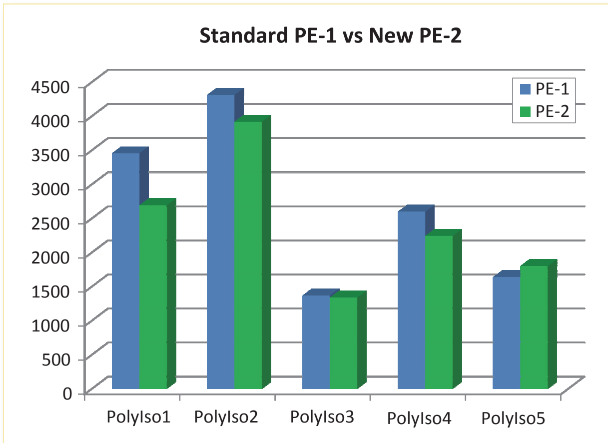


Figure 4—Initial viscosity using multiple polyisocyanates.

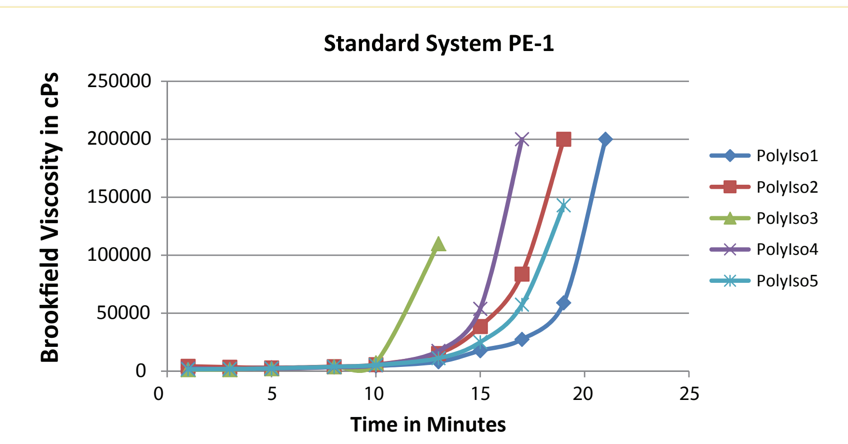


Figure 5—Working life of PE-1 using various polyisocyanates.

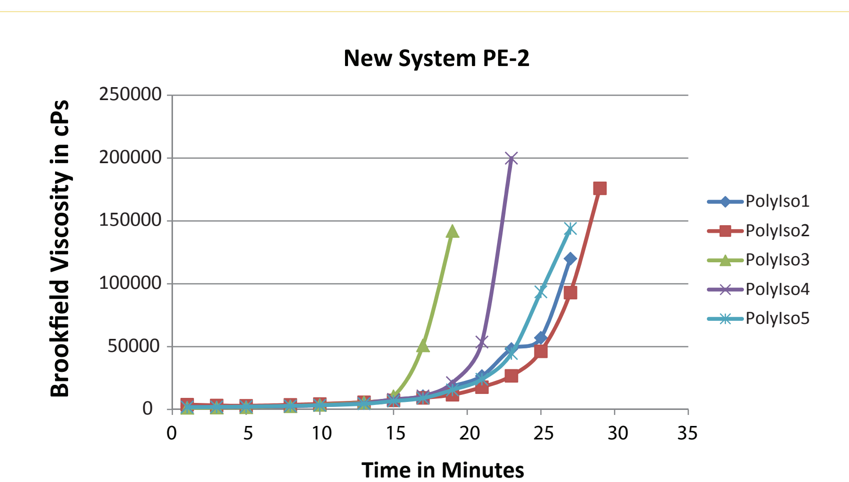


Figure 6—Working life of PE-2 using various polyisocyanates.

Castor oil-based polyols are used in the floor coating industry both in very high solids formulations and in waterborne formulations. For thick coatings (1/8 in. or greater) and for systems using cementicious materials, the waterborne option is the best since this provides the proper application rheology and the necessary water for hydration of the cement portion. The castor oil-based waterborne dispersions provide the inherent stability required in the water-based medium and the secondary hydroxyl groups provide adequate reactivity with aromatic-based polyisocyanate crosslinkers to form good coatings. There are advantages and limitations with this technology. The advantages are that it can provide very high build coatings with fast cure. The limitations are the flow and leveling characteristics, which can contribute to a rough appearance and short working life.

EXPERIMENTAL/RESULTS AND DISCUSSION

To address these problems, the typical castor oil-based polyol emulsion was modified for improved flow and leveling and increased working time. The emulsions were characterized for basic properties, which are shown in *Table* 1. Polyol emulsion 1 (PE-1) is the standard control and polyol emulsion 2 (PE-2) is the modified and improved version.

The flow behavior of the emulsion was evaluated using a typical formulation, as shown in *Table 2.*

The formulation was mixed under moderate shear for two to three minutes. Promptly, the contents were poured onto abraded concrete and troweled to achieve a uniform distribution. A spiked roller was used to release any entrapped air and further spread the material. The flow and leveling improvement of the modified polyol emulsion is shown in *Figure* 1.

Chemical Crosslinking, Viscosity, and Working Life

The typical crosslinking mechanism of this system is shown in *Figure* 2.

Table 3—Effect of Inorganic Materials on Work Life

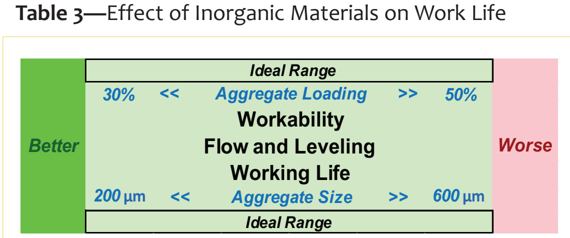


Table 4—Adhesion of Standard and New Systems to Concrete

Substrate	Topcoat	psi Adhesion
Aged abraded concrete	PE-1 Based Mortar	1241
	PE-2 Based Mortar	1543

The increase in viscosity of the system versus time using a standard polymeric MDI (PolyIso1) was measured using a Brookfield viscometer and is shown in *Figure* 3.

Figure 3 shows that the modified polyol dispersion has improved processing time, which is an advantage for the applicator.

The study was expanded in order to understand the effect of several different MDI-based polymeric isocyanates in the coating system. In *Figure* 4, the various polyisocyanates, including the previously tested PolyIso1, were reacted under similar conditions as previously described and the initial viscosity was recorded.

Also, as before, the viscosity versus time profile of PE-2 was compared with the PE-1 control and is shown in *Figures* 5 and 6, using the same range of polymeric MDIs.

These studies show that the working time can be adjusted and controlled by the selection of polyisocyanate.

Effects of Aggregate on Working Life

During mixing, heat is generated, which in turn can reduce the overall working life. Thus, it is advantageous to avoid prolonged shearing after thorough mixing of components. The size, shape, and loading levels of sand were also studied. Regarding shape, spherical sand as opposed to angular grades improved the working life. Additionally, it was discovered that the ideal sand loading was in the 30–50% range, while the fineness for optimum application and appearance was demonstrated to be from 200 to 600 microns. The results are summarized in *Table* 3.

These systems find use in high performance floor applications where extreme chemical resistance is required. The effects of strong caustic and acidic environments were evaluated and are shown in *Figure* 7.

The ASTM D7234—Pull-Off Adhesion Strength was evaluated for both systems and is shown in *Table* 4.

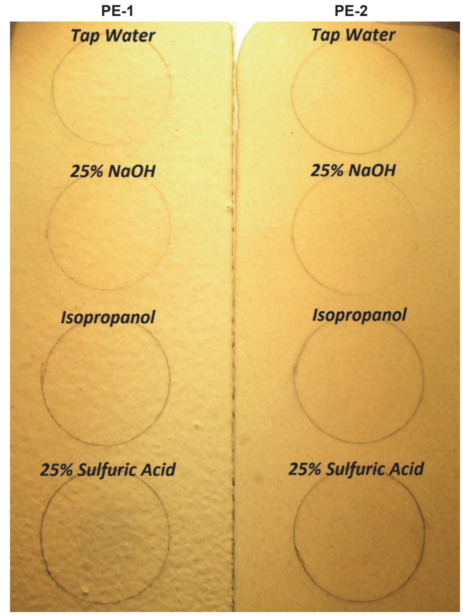


Figure 7—Chemical spot tests—24 hours covered exposure.

CONCLUSION

Castor oil-based polyols offer a natural and sustainable resource for the development of emulsions which, when used in the proper ratios with polyisocyanates and cementitious aggregates, provide quality high-build floor coatings. As illustrated, refinements are possible with this technology to further enhance application properties, increase working time, and improve the aesthetic appearance. CT

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