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Green crosslinking of epoxy resin using a novel eutectic hardener based on a plant-based acid mixtures

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PURPOSE OF THE ABSTRACT

A wide range of epoxy matrices that rely on unsaturated vegetable oils are economically viable sources and widely available for green epoxy matrices via established methods. However, there are fewer suitable bio-based hardeners that can cure at low temperatures, are cost-effective, and easy to handle without causing any health issues.

Citric acid (CA), tartaric acid (TA) or malic acid (MA) are naturally available, abundant, potentially multi-functional, relatively inexpensive, non-toxic, and already approved for food contact. They can form a branched network after reaction with epoxy resin. However, as their melting temperature are high, they cannot be properly mixed with the epoxy resin leading to heterogeneous cross-link density and poor network. To circumvent this issue, we present herein the innovative concept of eutectic hardener [1,2]. It consists in preparing a liquid hardening system in which CA, TA, or MA are combined with a liquefier to form an eutectic mixture able to cross-link epoxy resin ? even at room temperature. This process also allows combination of natural acids.

As shown in Fig. 1, mixtures containing a low amount of difunctional acid, 25 mol % TA to CA, increase stiffness, tensile strength, and toughness, corresponding to lower steric hindrance and better mobility of a difunctional acid to crosslink the polymer matrix (Fig. 2B). The addition of 25 mol% MA mixed to CA mixtures increases reactivity resulting in a higher glass transition temperature (Tg) and reasonable tensile properties in the final product. However, using mixtures with a higher mol% of MA complicates obtaining clear samples without inclusion of too many air bubbles.

These completely biobased and non-toxic systems, when cured with eutectic hardeners, result in flexible materials. Such flexibility is advantageous for flexible coatings (e.g. on textile), and decorative sheets for interior applications.

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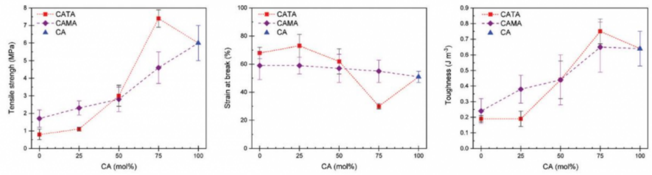
FIGURES



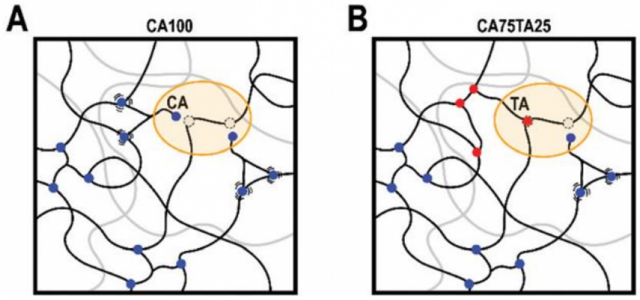


FIGURE 1

Tensile strength (left), strain at break (middle), and toughness (right) of the materials as function of acid composition. The dashed lines are meant to guide the eye to samples containing the same acid mixtures. These graphs are from the reference [1].

Figure 1.

FIGURE 2

(A) Hindered mobility of CA moieties after the vitrification of the sample leading to unconnected entities; (B) Illustration on how low amount of TA can help in cross- linking inaccessible oxirane moieties. These images are from the reference [1].

Figure 2.

KEYWORDS

Eutectic mixture | Carboxylic acids | Bio-based thermoset polymer | Epoxy resin

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