**Investigation of the Network Structure of Sustainable Epoxy Materials**

**from Vegetable Oils**

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**Introduction**

We study the structure of sustainable epoxy polymer materials obtained from vegetable oils. Diffusions of small organic molecules are facilitated within the cured networks in these materials. Cured networks of vegetable oils are obtained by carrying out photo-curing of epoxidized vegetable oils and other epoxy comonomers that enable the technological feasibility in coating and adhesive applications. We investigate the diffusion of small molecules in the cured networks of these materials using pulsed-field gradient (PFG) NMR1. Our aim is to understand the structure-dynamics correlations between the cured network density and the diffusivity of small molecules. In addition, solid-state NMR spectroscopy can be utilized to quantify the extent of unreacted epoxy residues and analyze the structure of the cured networks.

**Experimental**

Solid-state magic-angle spinning (MAS) NMR spectroscopy was utilized to investigate T1 relaxation time that is very sensitive to the extent of cross-linking of the macromolecular chains.2 Pulsed field gradient (PFG) NMR method was utilized to measure diffusion of small organic molecules, such as CHCl3, in the cured network. Epoxidized linseed oils (ELOs) were used for our experiments. We have utilized both 14.1 and 18.8 T solid-state NMR spectrometers for this project.

**Results and Discussion**

An increase in the extent of cross-linking in the cured solid material is easily reflected in the NMR T1 relaxation time. The cross-linking in the photo cross-linked ELO is believed to be enhanced by post-baking, resulting in an increased 1H T1 time (decreased relaxation rate) as shown in Fig. 1. T1 relaxation rate of the macromolecular matrix in the solid state would be decreased when the rigidity of the macromolecular chains increase due to the post-baking.

**Fig.1** Post-baking of the photo cross-linked ELO, and the changes in CHCl3 diffusion and T1 relaxation time before and after post-baking.

The swollen ELO material by organic solvent, such as CHCl3, exhibited two different diffusion coefficients: a fast component and a slow component (see Fig. 1). The enhanced cross-linking in the solid state ELO that may also increase the porosity in the swollen state has resulted in improved diffusions of the small organic molecules for both fast and slow components, particularly for the slow component.

**Conclusions**

The relative extent of the cross-linking in the epoxized vegetable oils has been improved by post-baking process as examined by T1NMR relaxation time in the solid-state. The diffusion of small organic molecules in the swollen state of this material after post-baking has also been improved as determined by PFG-NMR because of the increase of porosity in the solid matrix.

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**References**

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