

Modified Fatty acids as styrene replacements in vinyl ester resins: Influence of saturated fatty acid molecular weight on resin and polymer properties

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The Federal EPA increased legislation on hazardous emissions from composite manufacturing, which specifically targets styrene as a regulated hazardous air pollutant (HAP). One method of reducing styrene emissions from vinyl ester resins is to replace some or all of the styrene with fatty acid-based monomers. Fatty acid-based monomers are the better candidates because they have low volatility, free radically polymerize like styrene, promote global sustainability because they are derived from renewable resources and are inexpensive. Vinyl ester (VE) monomer was prepared by reaction of DGEBA based EPON 828 with methacrylic acid. Methacrylated fatty acids (MFA) were prepared by reaction of glycidyl methacrylate with saturated fatty acids with molecular weights ranging from 88 to 256 g/mol. Dynamic mechanical analysis of these systems showed that homopolymers of the MFAs exhibited a decrease in glass transition temperature as a function of fatty acid chain length suggesting that there are opposing mechanisms influencing the chain mobility of these polymers. Dynamic mechanical data of the VE/MFA binary systems show that a decrease in glass transition temperature is obtained with increasing chain length of MFAs which parallels the behavior observed for the MFA homopolymers. However, for VE/MFA binary blends there was an overall increase in viscosity with increasing fatty acid chain length. However, for the low range of molecular weight fatty acids a minimum in viscosity was observed for blends using methacrylated hexanoic acid. The VE/MFA binary blends exhibited viscosities that are too high for room temperature liquid molding applications ($>1000\text{cp}$) and Tg of these systems were all below $100\text{ }^{\circ}\text{C}$. Adding small amounts of styrene ($<15\text{ wt}\%$) was found to reduce the viscosity to acceptable levels ($<500\text{ cps}$) and raise glass transition temperature above $100\text{ }^{\circ}\text{C}$. The effects were found to be more pronounced for VE/MFA/Styrene systems using methacrylated butyric acid (MBut) compared to methacrylated lauric acid (MLau). However, the use of MBut with styrene was accompanied by the formation of lower Tg phases clearly discernable by DMA which was not observed for the higher molecular weight MLau. Nevertheless, the use of methacrylated butyric acid in conjunction with methacrylated lauric acid reduces viscosity, increases modulus, and the Tg as measured by the highest temperature transition obtained by DMA.