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The condensation of furfural with urea

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Abstract

The condensation of furfural with urea was conducted in aqueous and heterogeneous phases. In both of the synthetic procedures, the reaction was carried out using different furfural–urea molar ratios. The reaction in the aqueous phase was faster than the reaction in heterogeneous phase. The product's characterization was assessed by ^{1}H, ^{13}C and ^{15}N NMR, X-ray diffraction, FTIR, DTA, TG and DSC. The NMR spectra showed that the reaction product was always difurfurilidentriurea, independent of the furfural–urea molar ratio used in the syntheses. However, the results of X-ray diffraction study reveal differences in sample crystalinity. Thus, the products obtained from heterogeneous phase syntheses are more crystalline than those obtained from homogeneous reaction, and their cristalinity increases as the urea/furfural molar ratio increases. According to the thermal analysis, the product is stable until 160 °C. The melting point, at 205 °C, is accompanied by an endothermic decomposition.

Keywords: Furfural; Urea; Difurfurilidentriurea; Fertilizer

1. Introduction

Urea reacts with aldehydes yielding different polymeric materials. The product prepared from formaldehyde accounts for over 80% of the amino resins. Adhesives represent the largest production. They are used to make plywood, chipboard and sawdust board. Urea–formaldehyde polymers are also employed as the binder for the sand core and in the manufacture of foams (Updegraff, 1990). Agriculture is also one of the fields of application; for instance, polycondensation product with low molecular weight named as urea-form, has been used as a fertilizer since the 1940s (Clark et al., 1948).

Furfural is produced from renewable resources as agricultural or forestry waste (corn cobs, oat and rice hulls, sugar-cane bagasse, wood chips, etc.) by acid-catalyzed hydrolysis of polymeric pentoses followed by acid-catalyzed dehydration of aldopentoses (McKillip and Sherman, 1980).

The condensation of furfural with urea in neutral or acidic medium yields a low solubility product with around 25% nitrogen content suitable for fertilizer use (Mutinský and Švehla, 1976; Scholven-Chemie, 1967; García-Gómez et al., 1999). Under favorable conditions, the product is hydrolyzed yielding urea and furfural slowly and producing a twin effect, namely

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