Urea-Formaldehyde resins characterization by FTIR and TG-DTA

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Introduction

Urea-Formaldehyde resins are preferred by the wood-based panels industry due to their high reactivity and cost efficiency. Nevertheless, their main disadvantage is the low tolerance to humid conditions, which brings on progressive degradation of the ether bridges existed in the network of the resin and consequently persistent formaldehyde release from the UF-bonded wood panels. In this study, urea-formaldehyde resins of low formaldehyde to urea mole ratio were produced following two different synthesis procedures and investigated with application of Fourier Transform Infrared Spectroscopy (FTIR) and Thermogravimetry (TG-DTA).

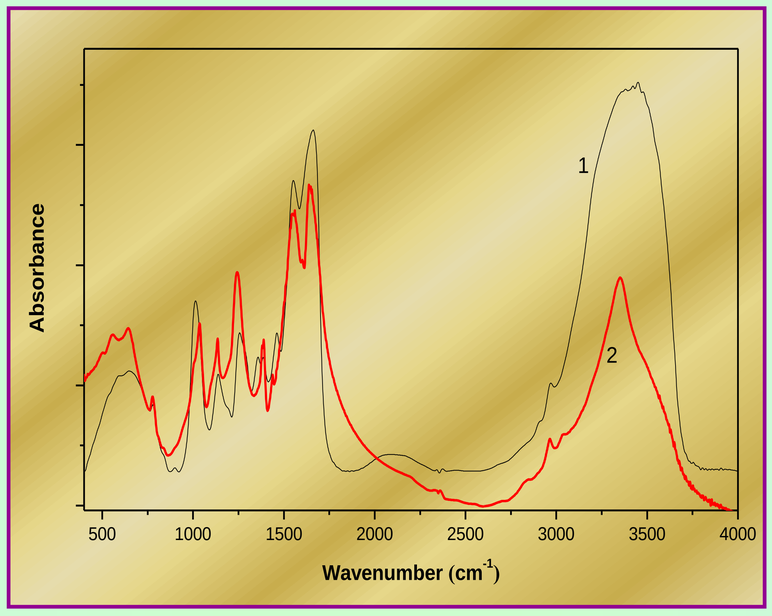
The new preparation procedure facilitates the production of resins having remarkable clarity when freshly prepared while the conventional resins of this low mole ratio F:U are opalescent and more usually thick white liquids. To make such resins as clear transparent liquids allows an instant visible means of checking that the resin made by this process has been supplied and that contamination by other materials has not taken place.

These advantages, can be achieved with no loss of strength in the resin. As it is obvious from the properties of particleboards made with this innovative UF resin both the internal bond (IB) and the thickness swelling (TS) of boards have been drastically improved, while the formaldehyde emissions remained comparable to the values of the conventional resin.

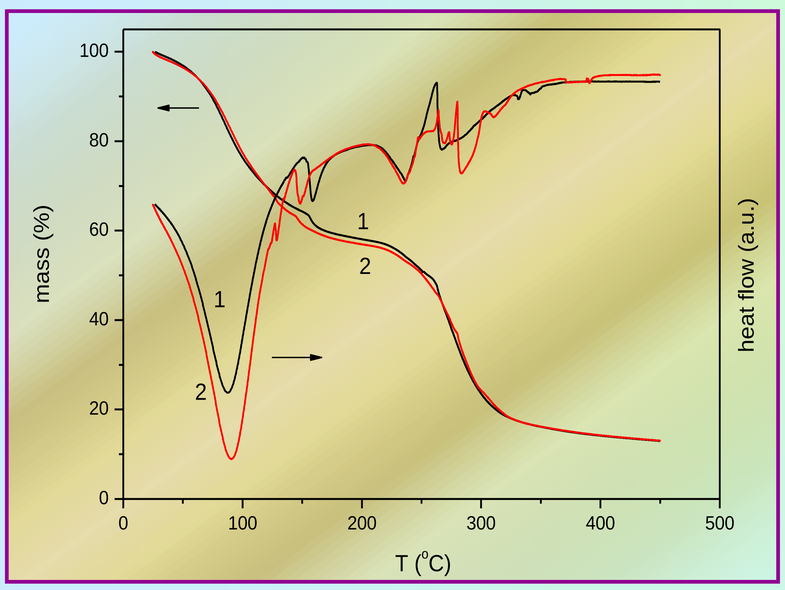
Results and discussion

Comparing the specifications of the two UF resins it is obvious that the new process gave product of very low buffer capacity and increased compatibility in water (water tolerance). These properties are very important for the industry because the low buffer capacity indicate the potentiality to reduce or even eliminate the use of acid for the hardening of the resin while the increased water tolerance renders good wash down properties to the product and allows the easy cleaning of the apparatus used for the uncured produced. All the other specifications of the resins are similar which means that no special treating of the resin is required for its application in board production.

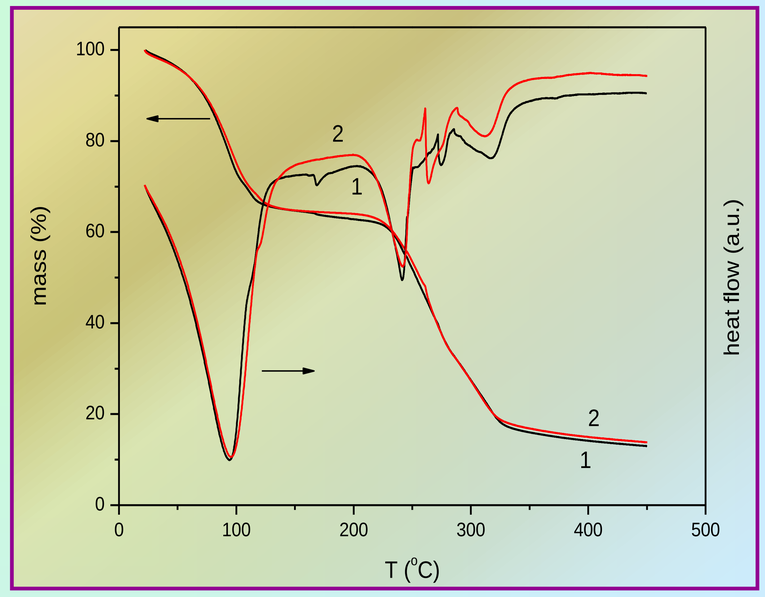
Properties of uncured resins	Value	Conventional resin	Innovative resin
pH at 25°C	[ ]	8,0	8,3
Brookfield viscosity at 25°C	cP	320	365
Hardening time at 100oC	s	50	49
Water tolerance (resin/water) at 25°C	ml / ml	1 / 2.5	1 / 4.3
Surface Tension	mN/m	71	72
Free Formaldehyde	%	0.060	0.070
Buffer Capacity (measured with 0,1N H_2SO_4)	ml	11.0	8.0

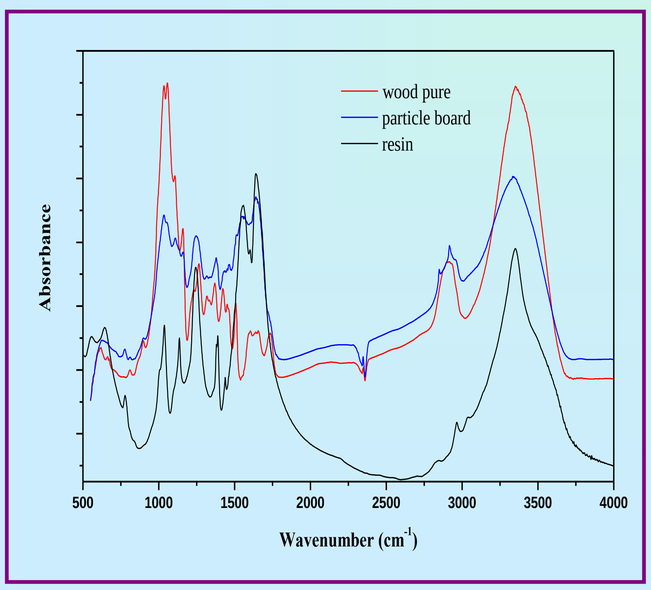


The absorbance spectra of the conventional and the novel resins are almost identical and the peaks that revealed could be attributed to the characteristic functional groups of the resin such as amide I, II and C=O at 1650-1550cm^{-1}, CH_2OH , CH_3 and C-N at 1400-1360cm^{-1} etc. The most characteristic difference between the pre-polymers and the totally cured resins is at the spectral area 3700-3000 cm^{-1}. The broad band of the prepolymer at ~3440 cm^{-1} -attributed to N-H stretching mode of the free NH_2 group-, after curing became sharper and shifted at 3350 cm^{-1}, indicating the formation of bonded –NH group. Moreover the broadening of this band could also be attributed to byproducts in the prepolymer, such as water and excess formaldehyde, which allow hydrogen bonding with the reactive functional groups such as –CH_2OH, -NH_2 and >NH

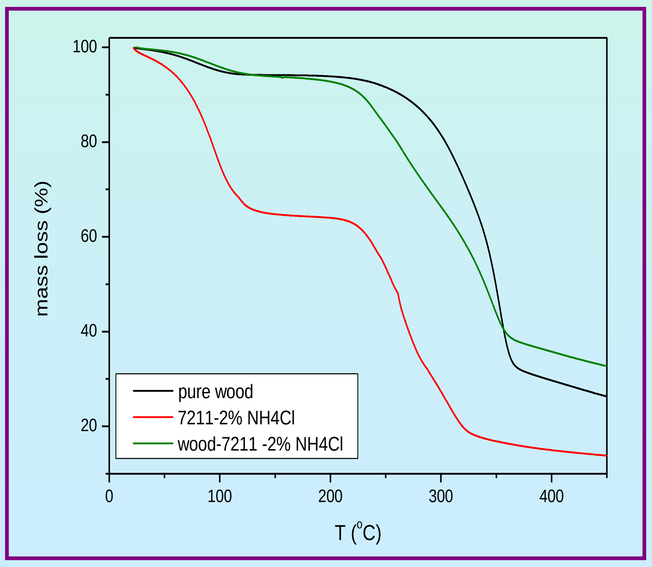


The curing of the resin is extended in a wide temperature area while any exothermic peaks are totally covered by the water evaporation. The high endothermic peak is attributed to water, which may comes up either from the quantity added during the synthesis of the resin or the mass resulted from the condensation reaction. No obvious thermal incident is observed in the area of temperatures beyond the water evaporation and up to 210°C, while a small mass loss corresponds to the free formaldehyde's slow release. The endothermic peak with minimum at 232-237 °C is attributed to the degradation of methylene-ether bridges in the resin's network. The comparative results of the pre-polymer and cured polymer for both the conventional and innovative resins show up that the maximum of the endothermic peak attributed to methylene-ether bridges comes about to lower temperatures for the pre-polymer than the cured resin. This shifting is wider in the innovative resin.





The FTIR absorbance spectra, obtained from small areas of the resin modified particle board present, except of the characteristic peaks of the resin, peaks attributed to the functional groups of the pure wood such as O-H (3600-3200 cm^{-1}), C=O acetyl in xylans (1735cm^{-1}), aromatic ring (1508, 1423, 1340-1315cm^{-1})



Conclusions

The innovative process is suitable for the production of low F:U mole ratio urea-formaldehyde resins. Such a resin is capable to produce particleboards and fibreboards effective for many applications with out changing the usual industrial production procedure. Even though the analysis of the resins with TG-DTA technique in dynamic heating conditions and FTIR didn't brought to light any significant differences proclaiming the superiority of the new process, both the specifications of the uncured resin and the properties of the boards manifest the advantageous properties and improved bonding ability of the innovative resin. This can be attributed to the synthesis parameters employed during the manufacture of the pre-polymer that allowed the development of a network with different structure and chemical bonds while the terminal or pendant chemical units remained qualitatively the same.