CHEMISTRY AND CHARACTERISTICS OF NATURAL AND CARBONIZED RIGID AND ELASTIC TANNIN FOAMS

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ABSTRACT

Tannin based rigid foams are natural network structures obtained by polycondensations of polyflavonoid tannins and furfuryl alcohol. These foams have a wide range of characteristics. Mimosa, quebracho and even pine tannin bark extracts were used as building blocks. Physical tests such as water absorption, compression resistance, direct flame behaviour and measure of foam cells dimensions were carried out for each foam sample. A ^{13}C-NMR analysis contributed to the chemical characterisation of the foams. Tannin based rigid foams appear suitable for a wide range of applications.

Tannin-based rigid foams, prepared from 95% natural material, are suggested for replacing synthetic phenol - formaldehyde foams in various applications. For that purpose, a few physical properties were measured: resistance to fire and chemicals, absorption of various liquids, permeability, thermal conductivity and mechanical (compressive and tensile) strength. Finally, slightly anisotropic mechanical properties were measured. The materials present a brittle behaviour, whether tested in compression or traction; nevertheless, their strengths, as well as their thermal conductivities, are fully comparable with those of their phenolic counterparts. Such materials of vegetable origins can compete with synthetic ones for most traditional applications.

Albumin-based rigid and elastic foams were prepared by mechanically beating water solutions of the protein mixed with formaldehyde and camphor. The resulting foams were cross-linked in a traditional or in a microwave oven. Formaldehyde was used as hardener of the protein and camphor as a plasticizer. Thermal conductivity was tested and found to be acceptable for thermal insulation but did not appear to be influenced by variations in foam density. Scanning electron microscopy of the different formulations showed some differences in cells structure. Formulations of different water content, formaldehyde hardener content, camphor content and oven curing time were tested. Within certain limits (a) increases in water proportion rendered the foam more elastic, (b) higher formaldehyde content increased foam rigidity and strength up to a value beyond which no further increase occurred, (c) The amount of camphor influences markedly the compression strength and foam elasticity/plasticity, (d) curing time improving foam strength up to 5 minutes in microwave curing, without any further effect for longer heating times. Only addition of glycerol, yielded truly soft elastic foams.

Flexible tannin foams as opposed to the rigid tannin foams already prepared, were obtained by the addition of an external (non-reacted) plasticizer, namely glycerol. Glycerol was chosen for its high boiling temperature and the lack of evaporation, coupled to its lack of toxicity. Flexible albumin protein foams were also prepared using glycerol as an external plasticizer. Flexibility and spring-back of these experimental foams when subjected to a cyclic compression force followed by spring-back and compression again was quantified by both thermomechanical analysis at different temperatures as well as by compression/spring back hysteresis cycle tests in a universal testing machine. Tannin foams containing formaldehyde and without glycerol have been shown to reach a stress plateau indicative of structure crushing. Tannin foams without formaldehyde but without glycerol too, becomes very fragile, brittle and rigid just two months after their preparation again presenting structure crushing with ageing. Instead, tannin foams without formaldehyde but with glycerol added do not show any change of flexibility with time and remain truly flexible. Albumin foams to which glycerol was added also do not show any change of flexibility with ageing. The glass transition temperature of the materials constituting the foams was measured by thermomechanical analysis.