Innovative Structural Modification Process of Kraft Lignin Using Flow System Approach

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Abstract

An innovative process of structural modification of kraft lignin (KL) followed by the incorporation of the herbicide picloram ($C_6H_3Cl_3N_2O_2$; CAS 1918-02-1) was developed by means the methoxylation reaction in a continuous flow regime. The modified KL-picloram nanoformulation obtained will be used in the study and validation of formulations of controlled release of the herbicide picloram in the subsequent stages in order to prove the environmental gain of this type of formulation against a convention formulation. It is expected that the structural modification will promote an improving of properties as surface area, adsorption and availability of chemical groups for interaction. The modification process, followed by the incorporation of the agrochemical molecule, in addition to being innovative, as it uses flow synthesis, meets the United Nations Sustainable Development Goals.

Methodology

KL was solubilized in a sodium hydroxide solution followed by formaldehyde (for methylation) and herbicide picloram (for incorporation) additions (Fig. 1). Reactions of KL modification were conduct in a flow system device (Asia, Syrris) with a later herbicide incorporation in a vessel. KL modification and picloram incorporation were confirmed by means FTIR (IRAffinity-1, Shimadzu) and TEM (EM902, Carl Zeiss).

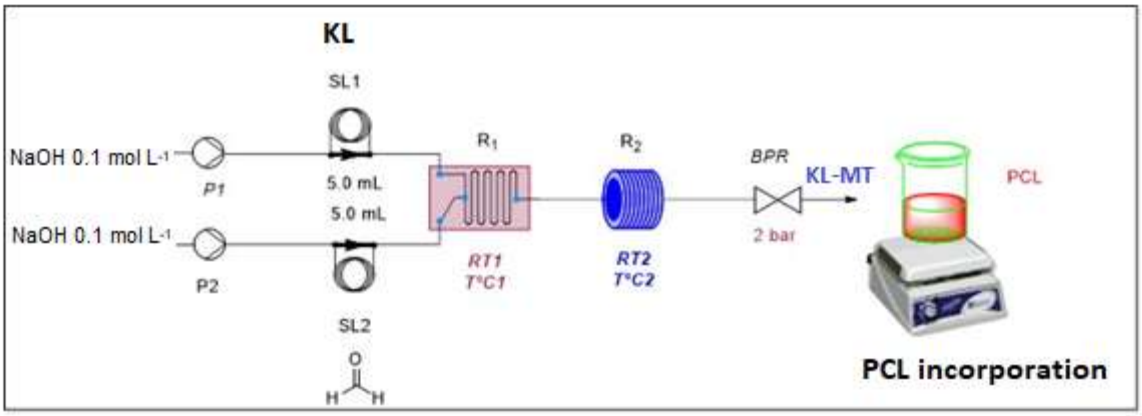

Fig. 1 Process developed for the structural modification of KL with subsequent incorporation of the herbicide picloram. KL = kraft lignin; Pn = system injection pump pressure in flow; SLn = solvent (formaldehyde) + kraft lignin solubilized in tubular reservoir; Rn = flow system reactors; RTn = reactor temperature; BPR = pressure regulator; KL-MT = methoxylated kraft lignin; PCL = picloram.

Results and discussions

Fig. 2 shows the confirmation of the modification of KL. Fig. 3 shows the confirmation of the incorporation of picloram to modified KL. The maximum size particle determined for the system modified KL-picloram was 97 nm.

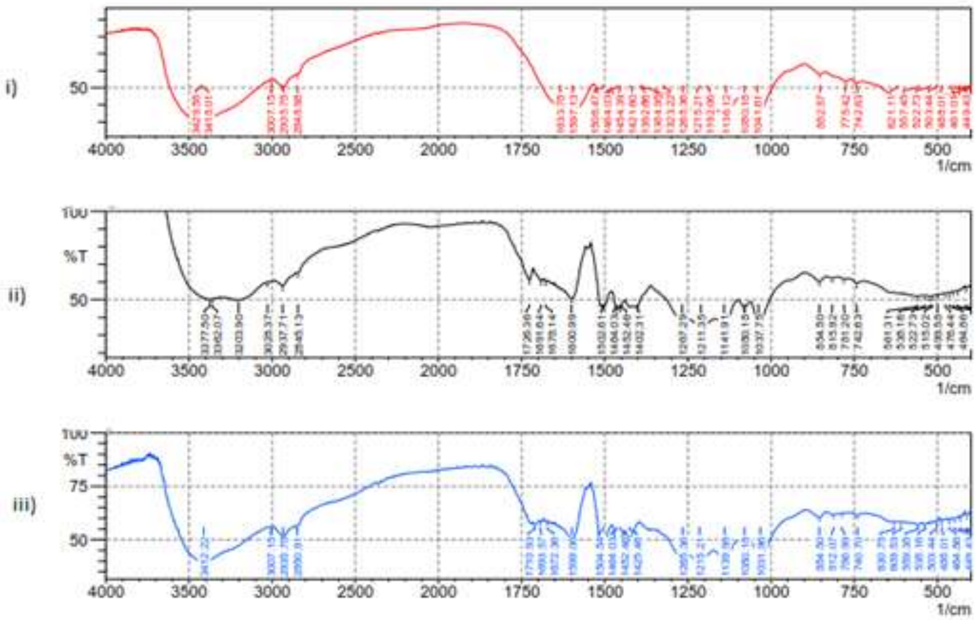

Fig. 2 FTIR spectrum of unmodified kraft lignin (i, red), batch modified (ii, black) and continuous flow modified (iii, blue). The region between 1750 and 1500 cm^{-1} stands out, where the alteration in the absorption bands can be observed produced by means the picloram incorporation.

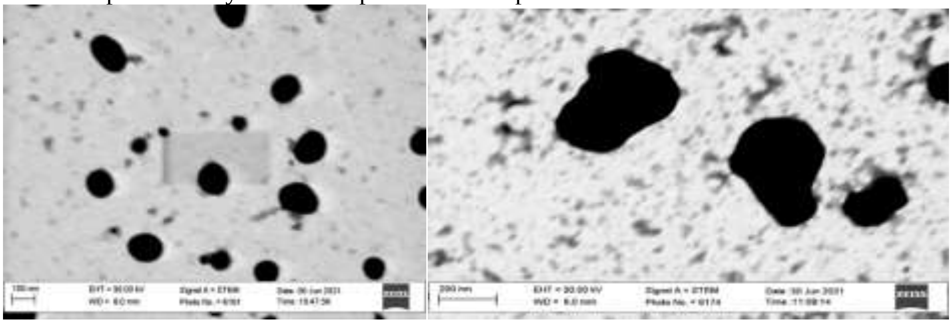

Fig. 3 Transmission electron microscopy of modified lignin (left) and picloram incorporated into modified kraft lignin (right). The picloram incorporation promoted the swelling of the kraft lignin particle.

It is expected that the structural modification will promote an improving of properties as surface area, adsorption and availability of chemical groups for interaction. Furthermore, the developed process is closely related to the United Nations Sustainable Development Goal 12 for responsible consumption and production.

Conclusions

It was concluded that the developed process using a methoxylation route in a continuous flow regime produced a modified KL-picloram nanoformulation with satisfactory physicochemical properties (particle size and encapsulation power) for its use in the further validation studies of the controlled release formulation in order to prove environmental gain against conventional formulation.

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