**SUPPLEMENTARY MATERIAL**

Characterization of lignin and lignin-derivatives from biomass. Application as expander of Lead-acid battery

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Scheme A1. Lignin extraction process for LigA1 and LigA1´ samples.

Scheme A2. Lignin extraction process for LigA2 y LigA3 samples.

Scheme A3. Lignin extraction process for LigB, LigC1, LigC2, LigC3 y LigC4 samples.

Scheme A4. Synthesis of lignosulfonates by microwave-assisted sulfonation

Table A1.

Synthesis process: weights and reagent composition

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *For 25 ml of Na2SO3* | | | *For 25 ml of Na2CO3* | | | *For 50 ml of NaHCO3* | | |
| *Lignin mass (g)* | | ***(g)*** | ***%(m/v)*** | ***Used (ml)*** | ***(g)*** | ***%(m/v)*** | ***Used (ml)*** | ***(g)*** | ***%(m/v)*** | ***Used (ml)*** |
| LigA1 | 0.1014 | 5.5237 | 22.1 | 1.5 | 1.0062 | 4.0 | 1.5 | 5.0004 | 10.0 | 7.5 |
| LigA1´ | 0.1007 | 5.5099 | 22.0 | 1.0642 | 4.3 | 4.9995 | 10.0 |
| LigA2 | 0.1085 | 5.4823 | 21.9 | 1.0011 | 4.0 | 5.0179 | 10.0 |
| LigA3 | 0.1055 |
| LigB | 0.2071 | 5.4851 | 21.9 | 3.0 | 1.0080 | 4.0 | 3.0 | 5.0282 | 10.1 | 15 |
| 0.2192 | 5.4959 | 22.0 | 1.0923 | 4.4 | 5.0304 | 10.1 |
| LigC1 | 0.1120 | 5.4897 | 22.0 | 1.5 | 1.0027 | 4.0 | 1.5 | 5.0513 | 10.1 | 7.5 |
| LigC2 | 0.1173 |
| LigC3 | 0.1026 |
| LigC4 | 0.0997 | 5.5066 | 22.0 | 1.0072 | 4.0 | 5.0011 | 10.0 |



Fig. A1. Comparison of UV-Vis spectra of lignins LigA1 and LigA1’ with commercial Vanisperse A.

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| **Lignos A3** |
| **Lignos C1** |

Fig. A2. 1HNMR spectra of some commercial lignosulfonates and those obtained in this work.

|  |  |
| --- | --- |
| **LignosA2**  Diagrama  Descripción generada automáticamente | **Indulin AT** Gráfico  Descripción generada automáticamente |
| **LignosC1** Gráfico  Descripción generada automáticamente | **Oak wood** Gráfico, Diagrama  Descripción generada automáticamente |

Fig. A3. COSY spectra of commercial lignosulfonates and those obtained in this work.

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