Humin based by-products from bioprocessing as potential carbonaceous source for synthesis gas production

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Electronic Supplementary Information (ESI)

1. Experimental

Water solubility of humin experiment was carried out and estimated based on "TAPPI T207 cm-99 Standard". Ca. 1g humin was refluxed in 100ml water in 250 ml Erlenmeyer flash. The flask with humin was placed in a boiling water bath for 3h. After that humin was filtered and dried to constant weight at 105 ± 3°C.

One percent sodium hydroxide solubility of humin was determined using "TAPPI T212 om-02 Standard". Ca. 1g humin was dispersed in 100 ml of 1% NaOH solution in a 200ml beaker. The beaker with a watch glass cover is kept in a water bath maintained at 98 ± 2°C for 60 minute. The solution was stirred with glass rod for about 5s at 10, 15 and 25 minute after placing in the bath. After 60 minute, humin was filter and washed with 100ml hot water then 25 ml CH_3COOH 10% (soaked for 1 minute before removal). The water – acetic acid washing was repeated 2 times. Then humin was washed with hot water until acid free. Finally humin (together with tarred filter paper) was dried to constant weight at 105 ± 3°C in a tarred drying cup.

Acetone extractives of humin was carried out according to "TAPPI T204 cm-97 Standard". An extraction thimble with ~1g humin was placed in a clean and dry Soxhlet extraction apparatus. 150ml acetone was used for the extraction. Heating power was adjusted so that it was allowed the solvent to cycle every ~ 10 min. The extraction was kept for 8 h. After that the solvent solution containing humin extracts was evaporated in a tarred extraction flask to near dryness. The flask was then dried in vacuum oven at 30°C for 1 h.

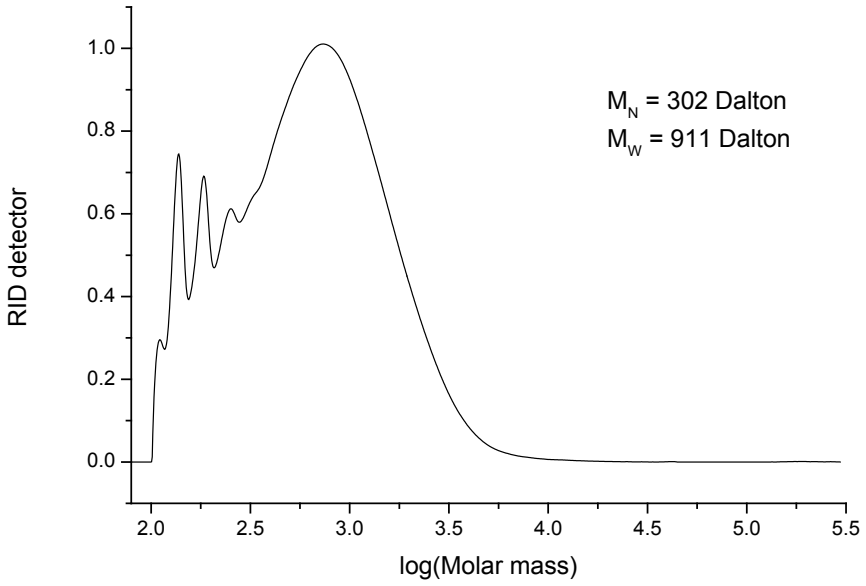
Solubility of humin was estimated as following:

$$\text{Solubility in hot water or 1\% NaOH} = 100\% \times \frac{w_0 - w}{w_0}$$

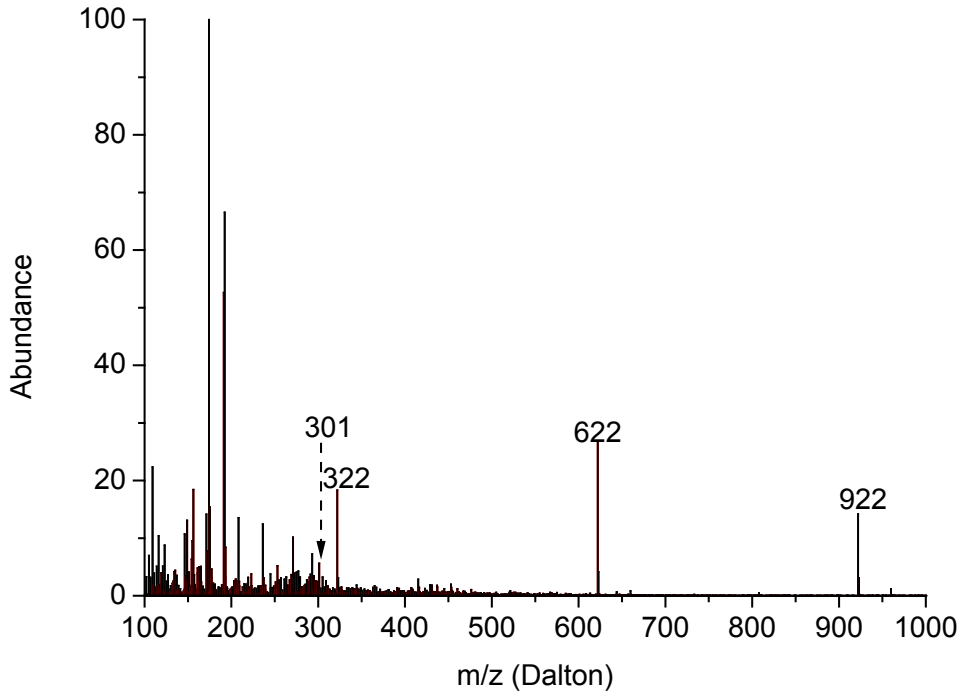
Solubility in acetone= $100\% \times \frac{w_e}{w_0}$

Where w_0, w and w_e is the oven-dry of humin before extraction and after extraction and oven-dry weight of extract after acetone extraction respectively.

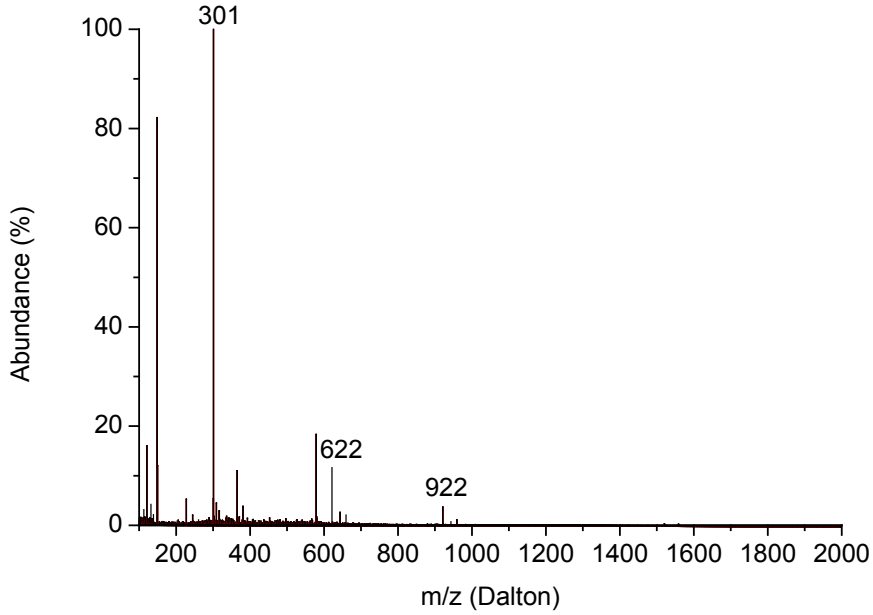
2. Results



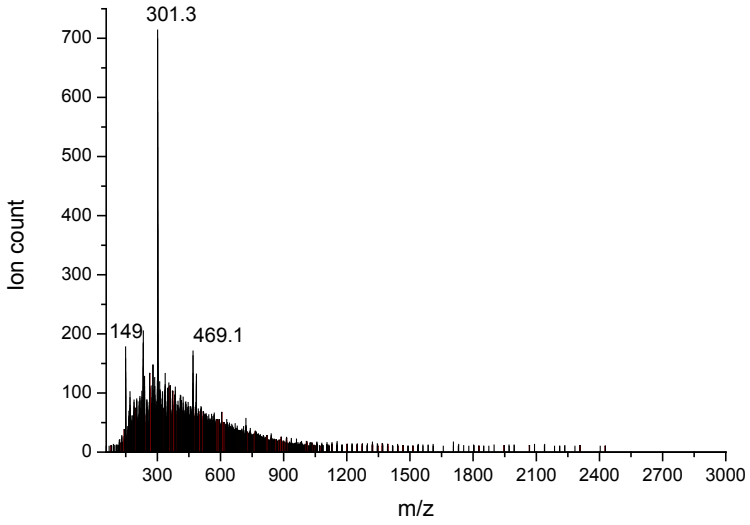
S1. GPC result of acetone soluble fraction of humin



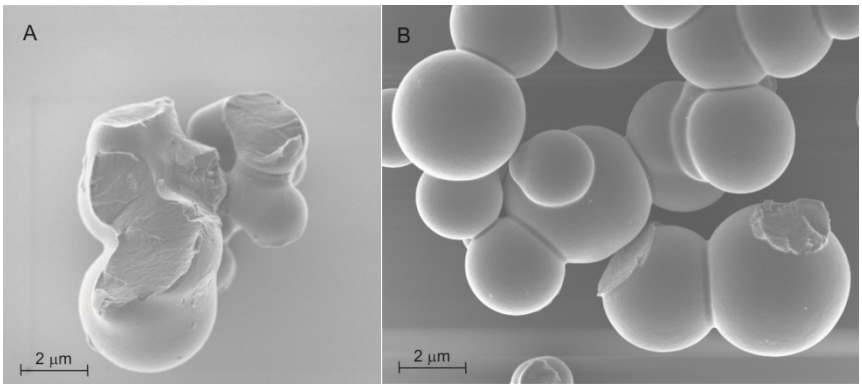
S2. ESI MS of solvent after the hot water soluble extraction of HG1



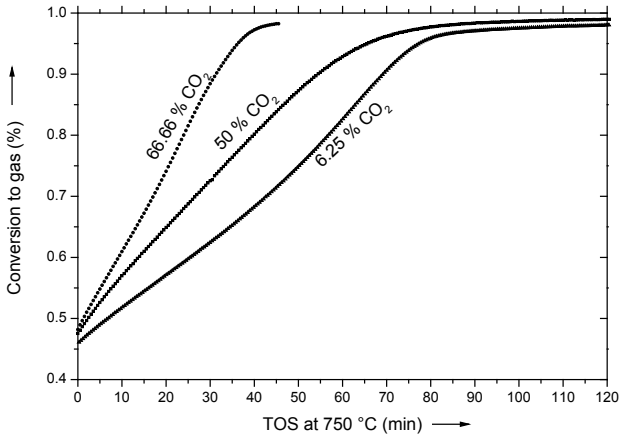
S3. ESI MS of solvent solution obtain in the experiment of NaOH 1% solubility of HG1



S4. LDI-TOF Mass spectrum of pristine humin



S5. SEM image of humin residue (A - HG1, B- HG1_NaOH 1%) after anealing in N_2 at 700 °C. No hollow sphere structure was formed



S6. The influence of CO_2 concentration in reactive gas stream on the conversion of humin