Disintegration of lignocellulosic biomass using Deep eutectic solvents: Degradation kinetics and Py-GCMS study

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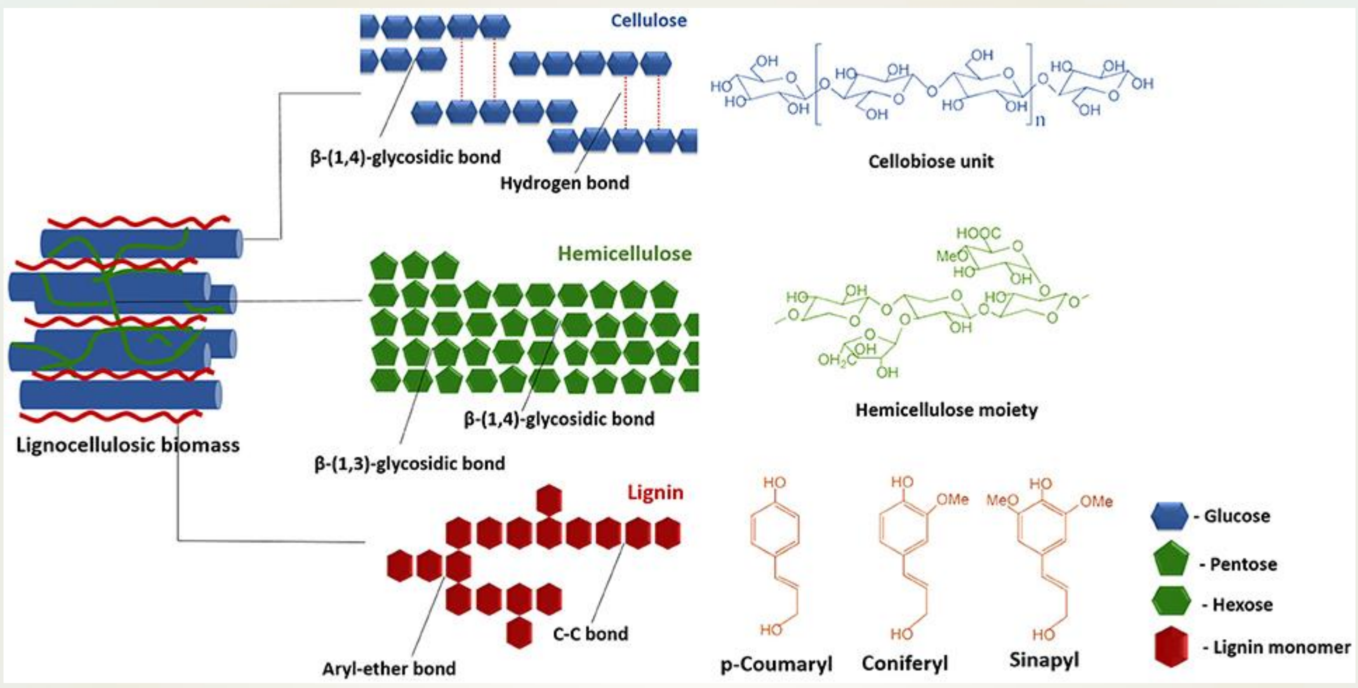
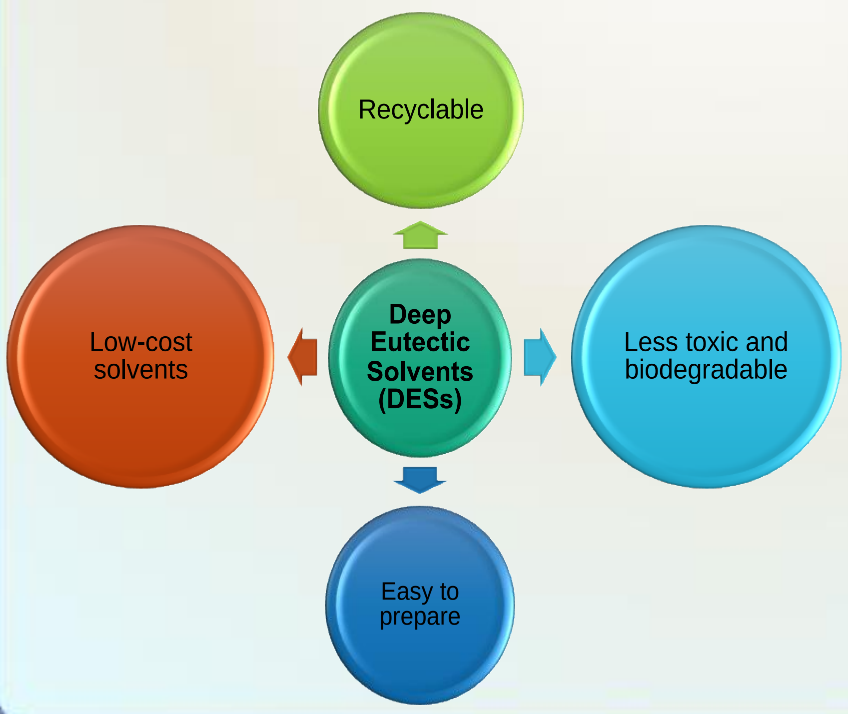
Introduction

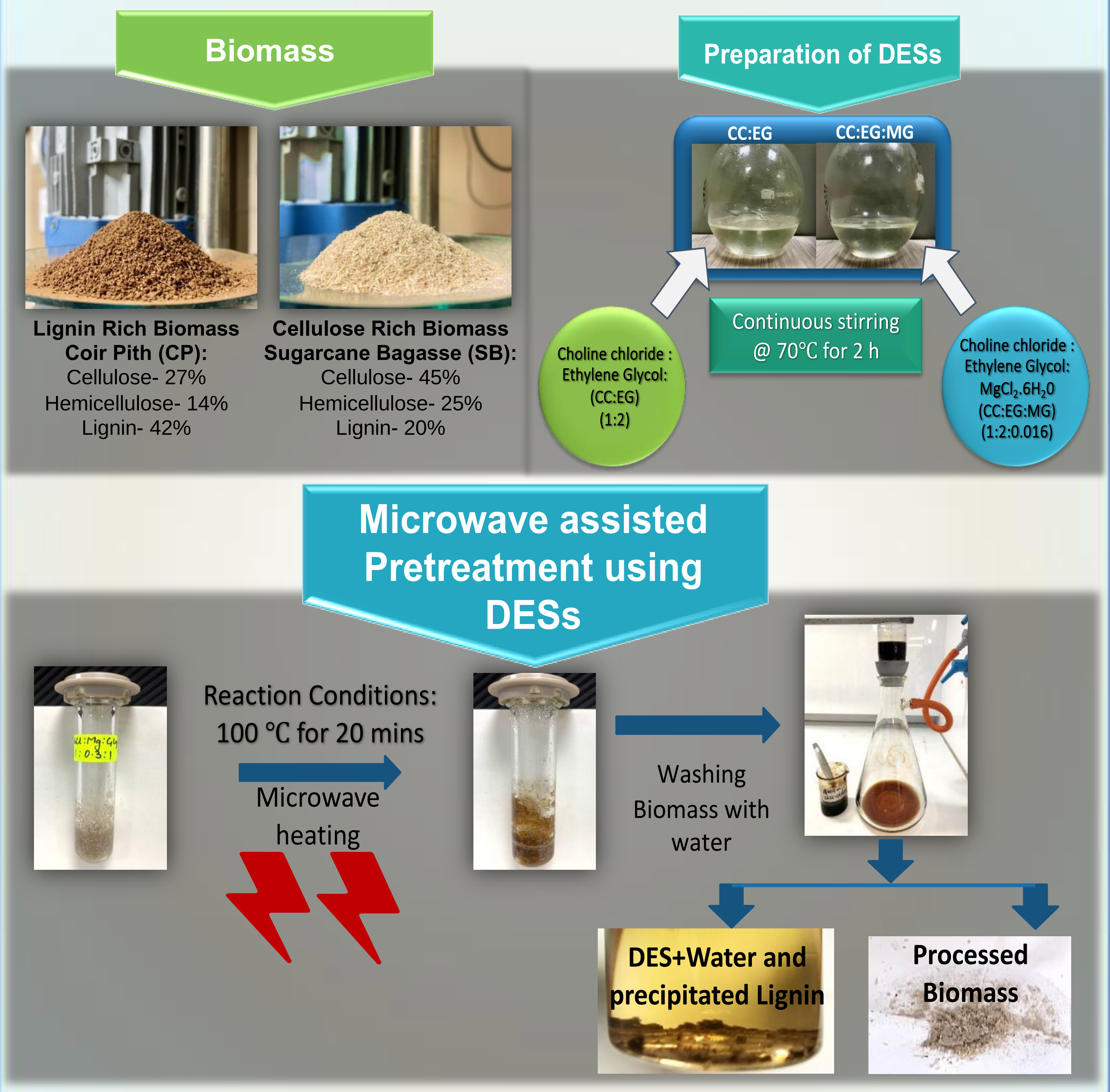
- Lignocellulosic biomass (LBM) represents a renewable, widespread and low-cost source which can potentially be converted to fine chemicals and bio-fuels.
- Fractionation of biomass is the most energy intensive, expensive and challenging step of biomass valorisation.





DESs are greener alternatives to ionic liquids having identical properties which can be used for the fractionation of biomass.

Materials and Methods

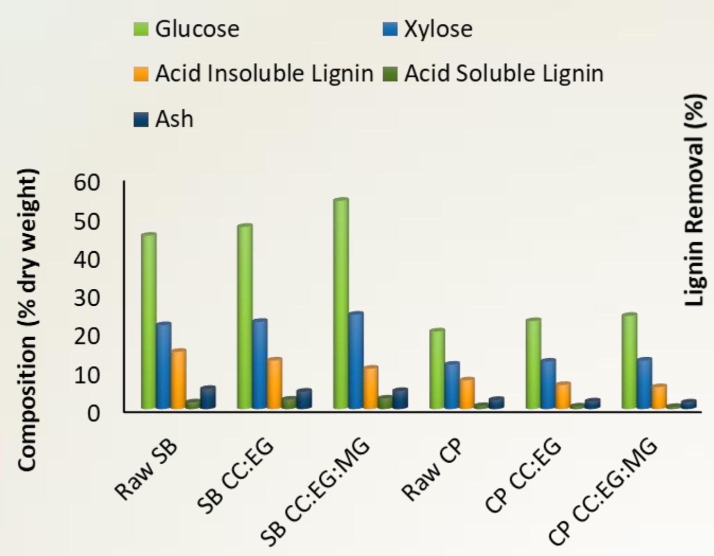


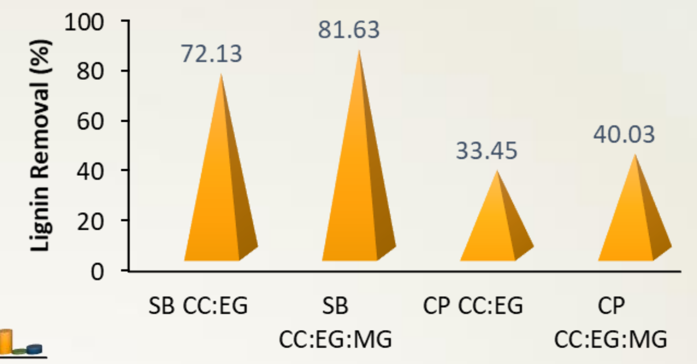
- A three-constituent DES system was used to compare its efficiency with the popular binary DES (CC:EG).
- Lewis acidic metal chloride salt ($MgCl_2$) was introduced to enhance the delignification process.

Results

- **Physicochemical characterization:**

SAMPLE	Volatile (wt.%)	Ash (wt.%)	C (%)	H (%)	S (%)	O (%)	HHV (MJ/kg)
CP-RAW	70.42	7.86	52.74	3.83	0.24	41.75	18.44
CP-CE	71.74	1.4	55.00	4.59	0.19	37.61	20.67
CP-CEM	72.28	1.81	55.16	4.80	0.19	37.46	20.98
SB-RAW	80.60	7.24	45.56	3.99	0.26	48.80	15.42
SB-CE	82.53	6.32	50.96	4.59	0.19	42.69	18.65
SB-CEM	83.14	6.33	50.15	4.74	0.17	43.16	18.49

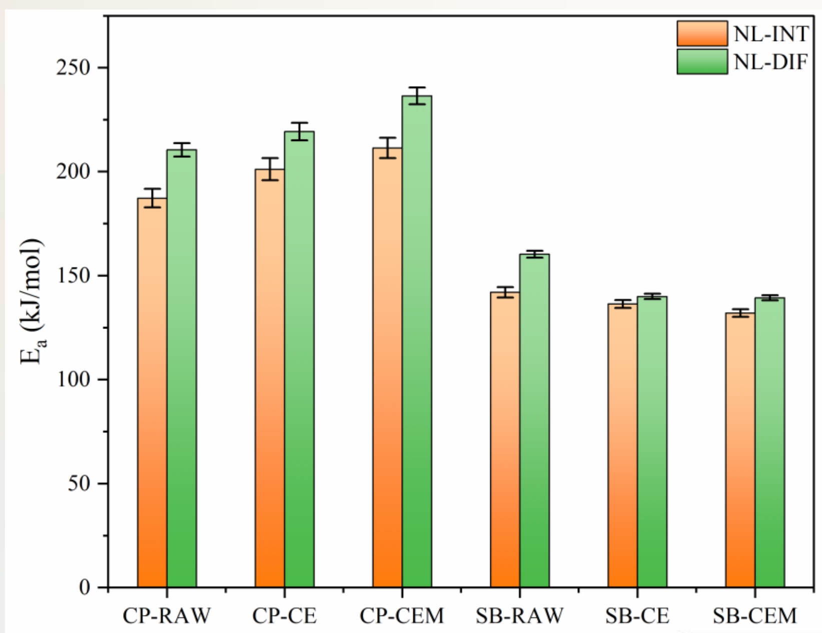




- **Degradation kinetics:**

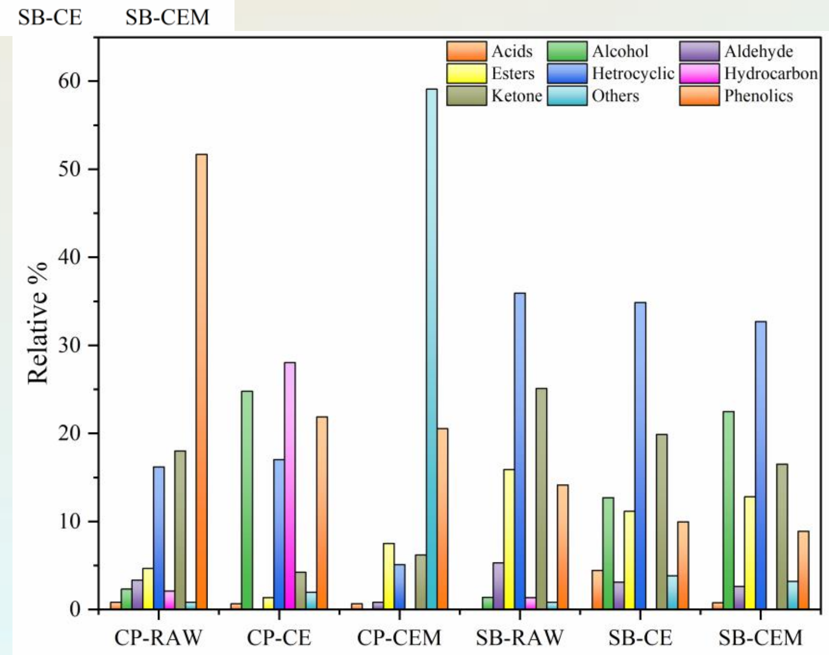
NL-INT: $$\left|\sum_{i=1}^{n}\sum_{j\neq i}^{n}\frac{\beta_j I(E_\alpha,T_{\alpha,i})}{\beta_i I(E_\alpha,T_{\alpha,j})}-n(n-1)\right|=\min(\Omega)$$

NL-DIF: $$\left|\sum_{i=1}^{n}\sum_{j\neq i}^{n}\frac{\beta_i\left(\frac{d\alpha}{dT}\right)_i\left[\exp\left(\frac{E_\alpha}{RT_{\alpha,i}}\right)\right]}{\beta_j\left(\frac{d\alpha}{dT}\right)_j\left[\exp\left(\frac{E_\alpha}{RT_{\alpha,j}}\right)\right]}-n(n-1)\right|=\min(\Omega)$$



- NL-INT & NL-DIF non-linear models are utilized in this study.
- After pre-treatment, E_a of CP increased while SB decreased due to less lignin removal occurring in CP.

- The Py-GCMS study has performed at a temperature of 550 °C.
- Phenolics and Heterocyclic are decreased gradually.
- Hydrocarbons and Esters are increased after DES treatments.



Conclusion

✓ Physicochemical properties of biomass has been improved after DES treatment.
✓ Lignin inhibited the reaction rate, and cellulose played the dominant role in the E_a.
✓ Py-GCMS study revealed that, Phenolics compounds decreased drastically after pre-treatment.
✓ Ternary DES (CC:EG:MG) showed better lignin removal efficiency than binary DES (CC:EG).
✓ Kinetic parameters are of great importance to large-scale reactor optimization.