Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary Materials

Synergistic effect of lignin incorporation into polystyrene for producing sustainable superadsorbent

Nasim Ghavidel[a], Pedram Fatehi[a]*

[a] Green Processes Research Centre and Chemical Engineering Department, Lakehead University, 955 Oliver Road, Thunder Bay, ON, Canada, P7B5E1

*Corresponding author: email: pfatehi@lakeheadu.ca; tel: 807-343-8697; fax: 807-346-7943

Results and discussion

Polymer characterization

Table S1 lists the properties of KL, KL-PS and PS. The increase in the C/H ratio via polymerization depicts the increment in the proportion of aromatic double bonds, i.e., benzyne group, in kg mol-1 than KL-PS (MW of 296 kg mol-1), inferring that the homopolymerization of styrene was more favored than its polymerization with lignin in the reaction.

Table S1. Properties of KL, KL-PS and PS.

Sample	C (wt%)	H (wt%)	O (wt%) *	MW (kg mol^{-1})	Surface area (m^2 g^{-1})	Pore volume (cm^3 g^{-1})
KL	64.5	6.1	27.7	29±4**	24	0.035
KL-PS	71.3	5.6	22.1	296±15**	44	0.053
PS	91	8.5	0	880±20***	15	0.021

* based on mass balance

** GPC results

***SLS result

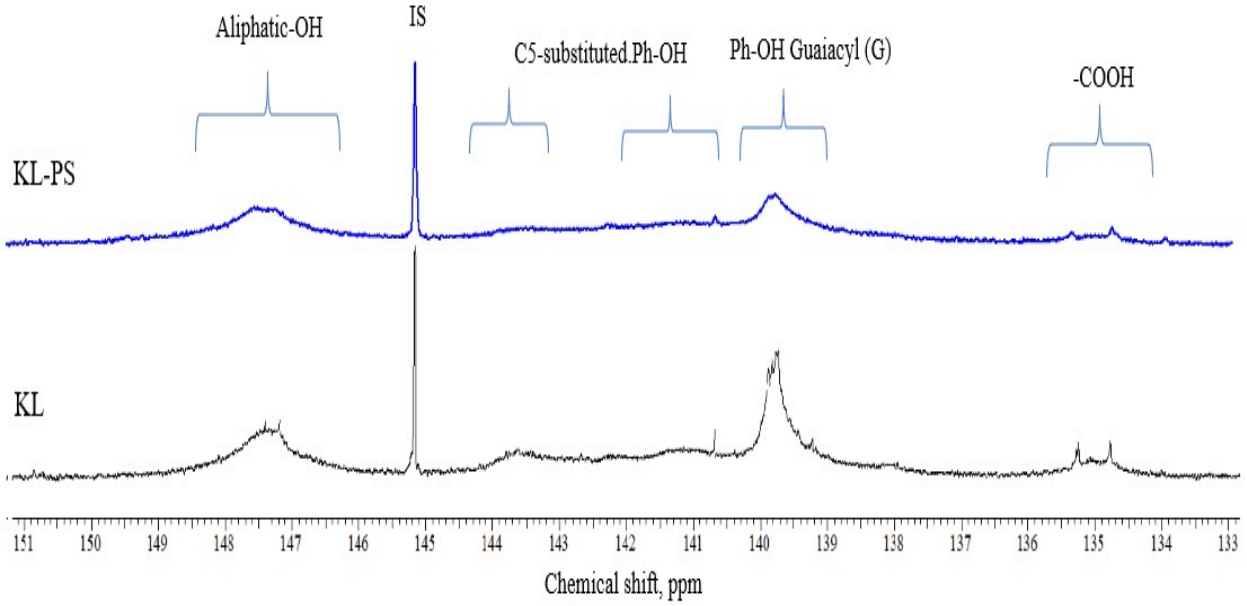


Figure S1. P-NMR spectra of KL and KL-PS

Table S2. Surface tension of the test liquids and polar, dispersive, acidic and basic components.[1]

σ (mN m^{-1})	water	diiodomethane	glycerol
Total	72.8	50.8	63.4
Dispersive	26.4	50.8	37.0
Polar	46.4	-	30.0
Acidic (+)	23.2	-	3.92
Basic (-)	23.2	-	57.4

Surface properties of PS, KL and KL-PS substrates

Contact angle of water, diiodomethane and glycerol on the PS, KL and KL-PS coated substrates are summarized in Table S3, and also images of the water droplets' contact angle on the substrates using sessile drop measurements are available in Fig. 3. Film generated via coating KL on the glass

slide had a contact angle of 50.2° for water droplets. Contact angles of water droplet in the range of 46° and 60° were reported for lignin film on glass slides,[2,3] and differences in results are originated from the difference in the type of lignin used.[3] The water droplet's contact angle on PS coated surface was 85.5°. The incorporation of lignin into PS reduced contact angle of KL-PS to 63° compared to PS. This reduction is originated from the introduction of functional groups in the final KL-PS product.

Table S3. Contact angles (°) of the test liquids on the coated KL, KL-PS and PS Films

Surface	water	diiodomethane	glycerol
KL	50.2±1	22.53±0.5	49.6±1
KL-PS	63.1±0.4	22.6±0.5	52.2±0.1
PS	85.5±2	35.2±1	86.3±2

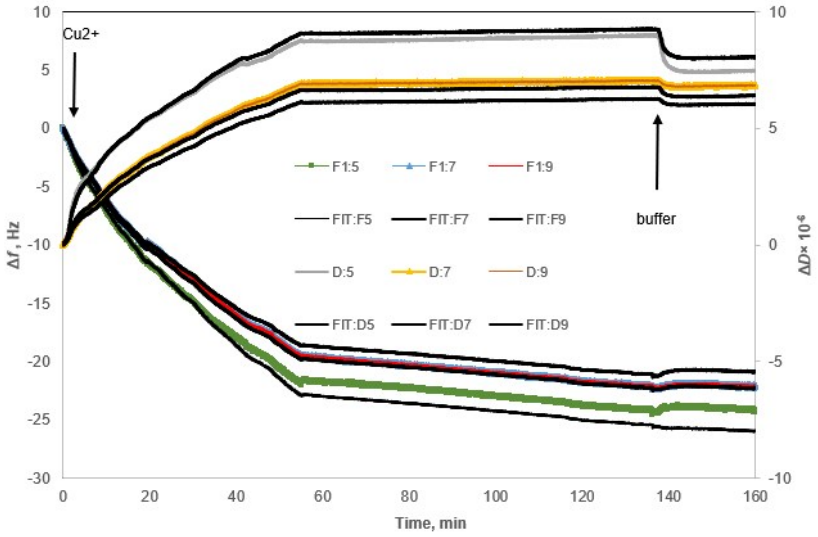
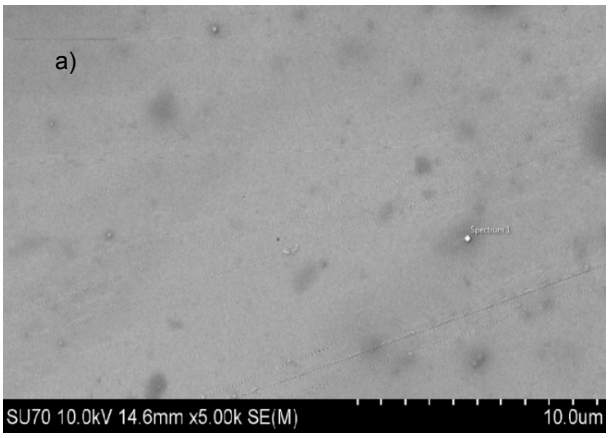
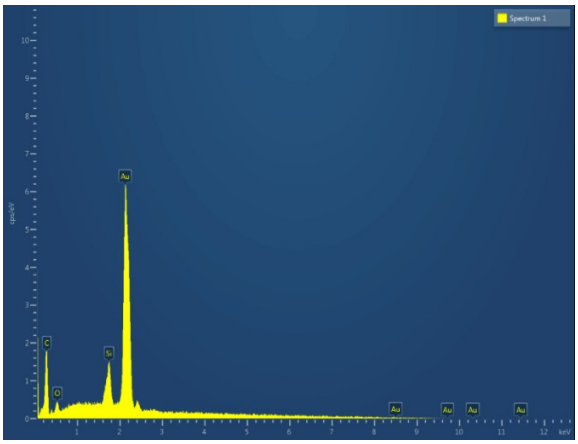


Figure S2. representative *Δf* and Δ*D* vs time curves for Cu^{2+} adsorption on KL-PS surface. Black lines show the fitted Voigt model for the adsorption of Cu^{2+} on the KL-PS coated sensors.


a)
SU70 10.0kV 14.6mm x5.00k SE(M)
10.0um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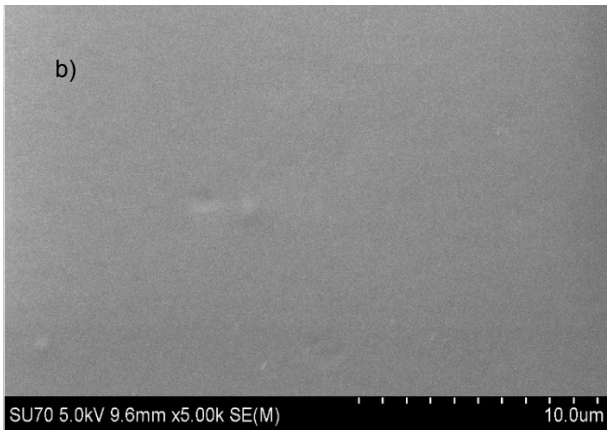
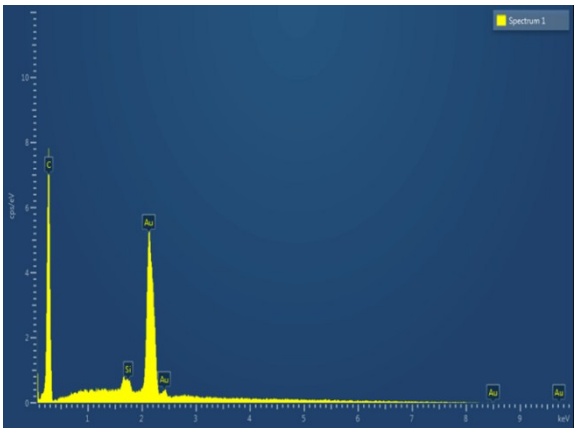
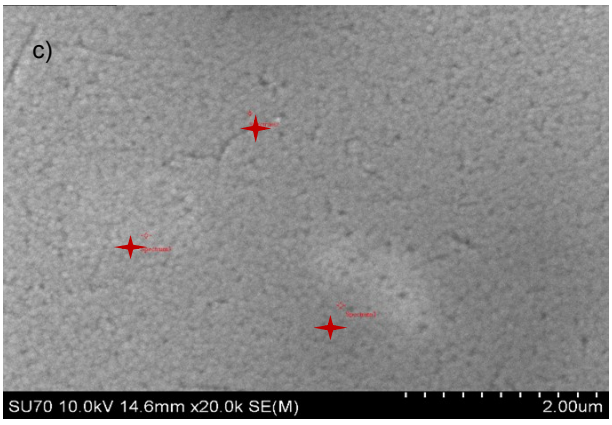
Au
C
Si
O
Au
Au
Au
Au


b)
SU70 5.0kV 9.6mm x5.00k SE(M)
10.0um


Spectrum 1
C
Au
Si
Au
Au
Au


c)
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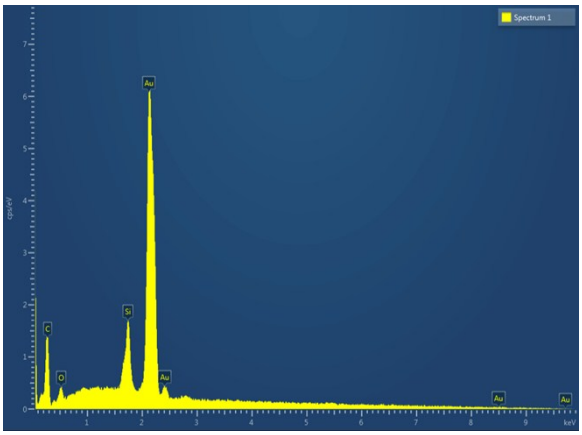
2.00um


Spectrum 1
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C
Si
O
Au
Au
Au

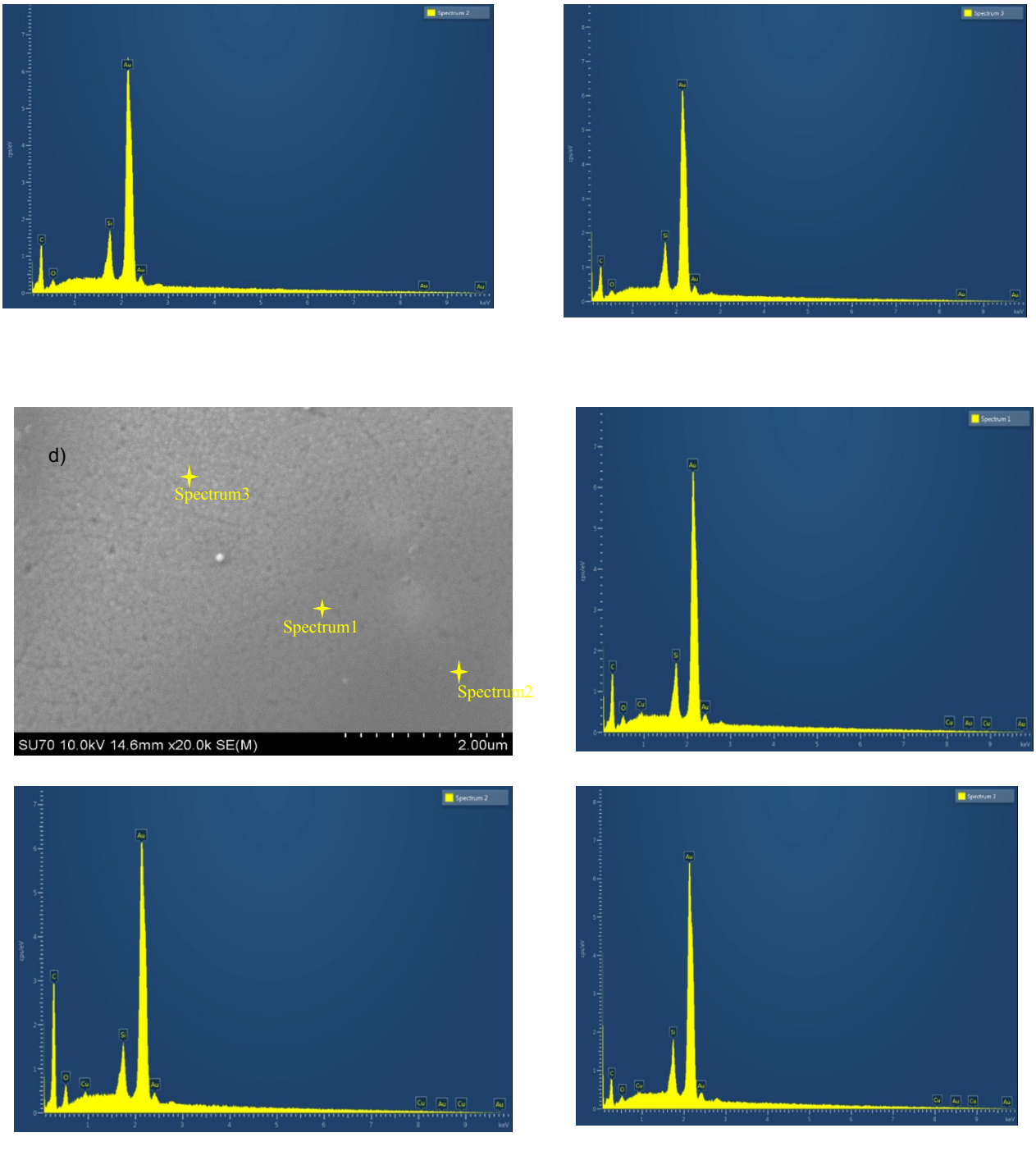

Figure S3. SEM/EDX images of coated gold sensors a) KL b) PS and KL-PS c) before and d) after Cu^{2+} adsorption in different areas.

References:

1. E. M. Harnett, J. Alderman and T. Wood, *Colloids Surf. B*, 2007, **55(1)**, 90-97.
2. S. M. Notley and M. Norgren, *Langmuir*, 2010, **26**, 5484-5490.
3. M. Norgren, S. M. Notley, A. Majtnerova and G. Gellerstedt, *Langmuir*, 2006, **22**, 1209-1214.