Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information

Lignin-based highly sensitive flexible pressure sensor for wearable electronics

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Table S1. Electrical conductivities of CL and CL/PDMS composites.

Electrical conductivity	CL	PDMS	CL/PDMS
Average (S/m)	28.01	$1.26*10^{-11}$	1.72
SD (S/m)	1.52	$1.12*10^{-12}$	0.13

Figure S1. The bulk -shaped carbonized lignin.

Figure S2. Resistance mesureament of (a) bulk-shaped carbonized lignin (80 mm x 24 mm x 10 mm) and (b)

CL/PDMS composite (20 mm x 20 mm x 1 mm).

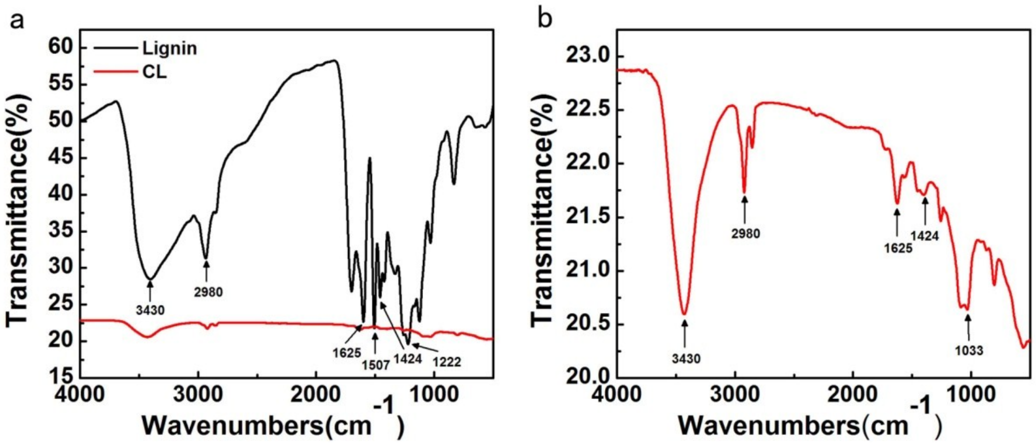

Figure S3. FTIR spectra of lignin and carbonized lignin (a), the amplified spectrum of carbonized lignin (b).

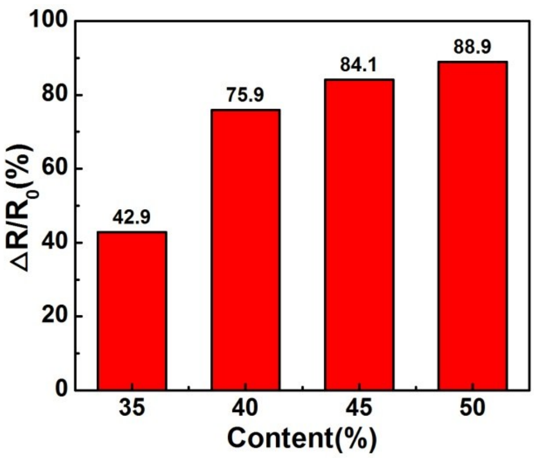

Figure S4. Relative change of resistance of CL/PDMS with different CL. (content: the CL content in PDMS, that is, the total content is 25.9%, 28.6%, 31.0%, 33.3%, respectively.)

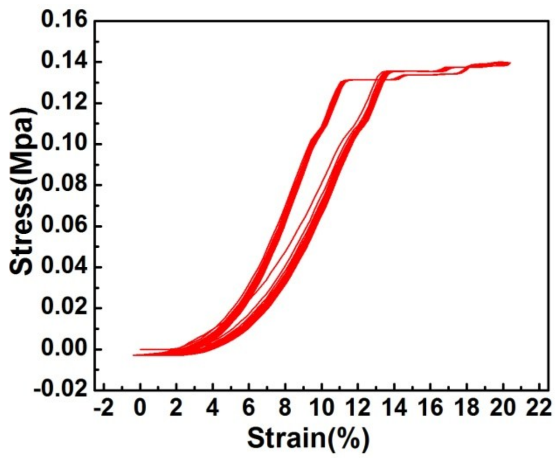

Figure S5. The stress-strain curve of the CL/PDMS composite under cyclic pressure.

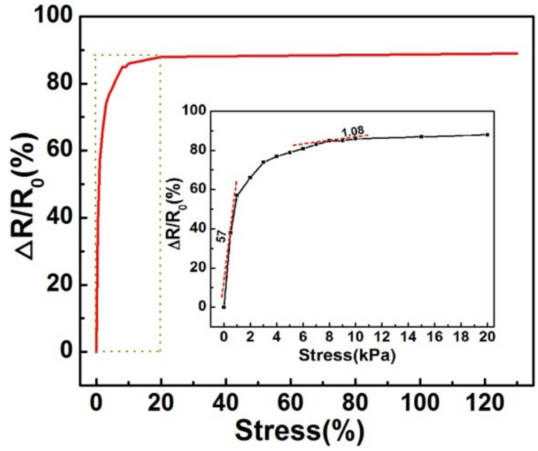

Figure S6. Relative change of resistance with stress.

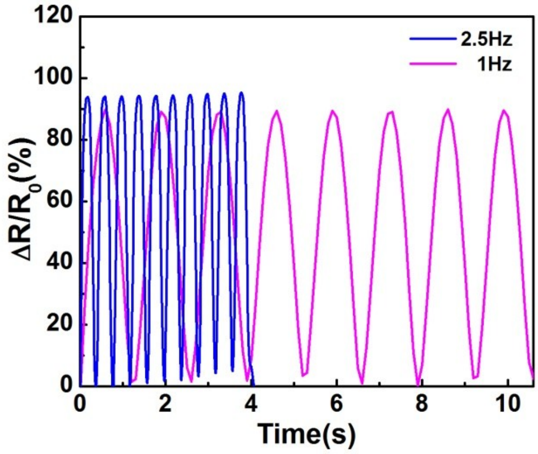

Figure S7. Response of CL/PDMS at different frequency (120kPa).

The derivation of tunnel resistance equation:

$$R_{tunnel} = \frac{V}{aJ} = \frac{2}{3}\frac{h^2 s}{ae^2\sqrt{2m\emptyset}} exp\left(\frac{4\pi}{h}\sqrt{2m\emptyset}\, s\right) \qquad (1)$$

Equation (1) is derived from the equation (25) in the reference 35 and the process is as follows:

Based on the equation

$$J = \frac{3\sqrt{2m\phi}e^2 V}{2s\quad h^2}\exp\left(-\frac{4\pi s}{h}\sqrt{2m\phi}\right) \quad (the\ equation\ (25)\ in\ the\ reference\ 35)$$

the area resistance R_{tunnel}=V/(a.J) can be given by

$$R_{tunnel} = \frac{V}{aJ} = \frac{2}{3}\frac{h^2 s}{ae^2\sqrt{2m\emptyset}}\exp\left(\frac{4\pi}{h}\sqrt{2m\phi}\, s\right)$$

where *a* is cross-sectional area of tunnel, *V* is the potential difference between the conductive particle, *J* is the tunneling current density, *e* is the quantum of electricity, *m* is the mass of electron, *h* is the Planck's constant, *s* is the distance between CLs in the insulating material and ϕ is the height of potential barrier. This equation is similar to that in the report

(*DOI:10.1016/j.mseb.2017.02.012*). The equation (1) is suitable for the description of tunneling effect of the CL/PDMS sensor under the condition of low voltage. The reason is that there are huge number of CL particles across the composite and the voltage applied to the composite is only 1V , therefore, the voltage between two conductive particles can be considered to be close to 0V.