

## Electronic Supplementary Information

### **$\beta$ -cyclodextrin enhanced triboelectrification for self-powered phenol detection and electrochemical degradation**

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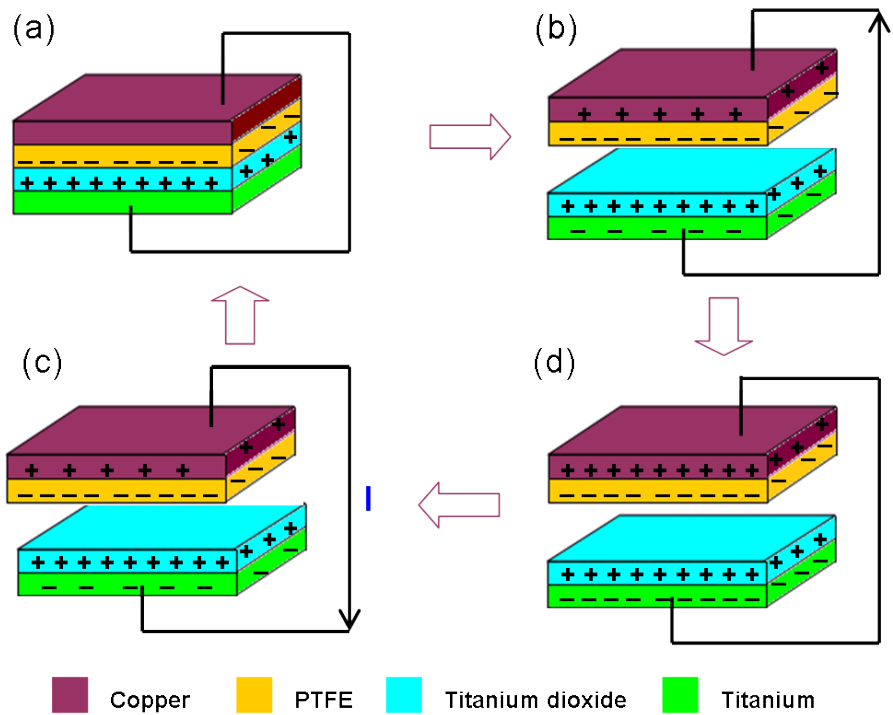
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**Fig. S1.** An illustration of the electricity generation processing of the triboelectricification. (a) An initial contact of titanium dioxide with the PTFE brought about charger transfer due to their different electron affinity, resulting in positive charges on the titanium dioxide and negative ones on the PTFE. (b) Electrical potential difference emerges due the surfaces separation, which drives the electrons from the Cu electrode to Ti electrode. (c) With continuously increasing the separation, almost all the positive triboelectric charges are screened at the maximum separation. (d) Electrons are driven back from Ti electrode to Cu electrode as the two plates are approaching each other.

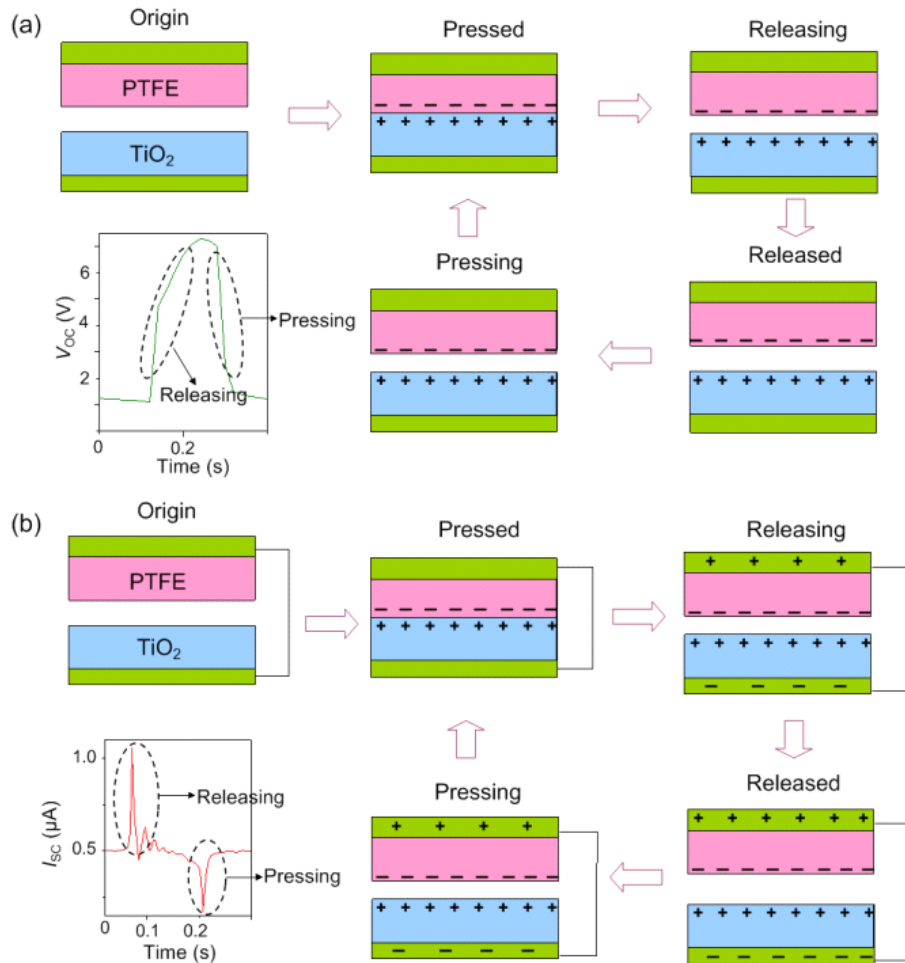


Fig. S2. Sketches that illustrate the opening principle of the triboelectrification. (a) Open-circuit condition. (b) Short-circuit condition.

In the open-circuit condition, electrons cannot transfer between electrodes. The open-circuit voltage is then defined as the electric potential difference between the two electrodes, that is,  $V_{oc} = U_{top} - U_{bottom}$ . At origin state, no charge is generated or induced, with no electric potential difference (EPD) between the two electrodes shown in Fig. R3 (a). With an externally applied force, the two materials are brought into contact with each other. Surface charge transfer then takes place at the contact area due to triboelectrification. As the external force to be released, the PTFE tends to revert back to its original position. Once the two materials separate, an EPD is then established between the two electrodes. The initial state corresponds to the maximum potential on

top electrode and the minimum potential on bottom electrode, which results in the maximum  $V_{oc}$ . As the generator is being released,  $V_{oc}$  increases until reaching the maximum value when the PTFE fully reverts to the original position. If pressing is immediately followed, the EPD starts to diminish as the PTFE and  $TiO_2$  layers get closer to each other. As a result,  $V_{oc}$  drops from the maximum value to zero when a full contact is made again between the PTFE and  $TiO_2$ .

If the two electrodes are connected, that is in short-circuit condition, as shown in Fig R3(b), free charges can redistribute between electrodes due to the electrostatic induction. And the established EPD between electrodes will drive electrons to flow from the top electrode to the bottom electrode in order to balance the generated triboelectric potential, resulting in an instantaneous positive current during the releasing process. The net effect is that induced charges accumulate with positive sign on the top electrode and negative sign on the bottom electrode. Once the generator is pressed again, reduction of the interlayer distance would make the top electrode possess a higher electric potential than the bottom electrode. As a consequence, electrons are driven from the bottom electrode back to the top electrode, reducing the amount of induced charges. This process corresponds to an instantaneous negative current. When the two polymers are in contact again, all induced charges are neutralized.

In short, the open-circuit voltage ( $V_{oc}$ ) switched between zero and a plateau value, respectively corresponding to the contact position and the original position. The short-circuit current ( $I_{sc}$ ) exhibits an alternating behavior, with an equal amount of electrons flowing in opposite directions within one cycle.

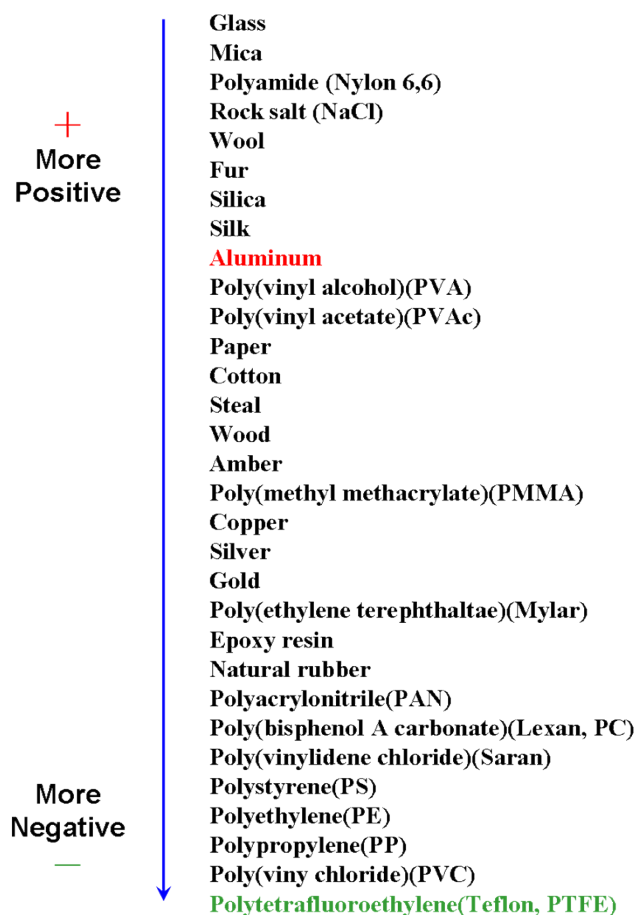


Fig. S3. Triboelectric series for some common materials following a tendency to easily lose electrons (positive) and to gain electrons (negative).

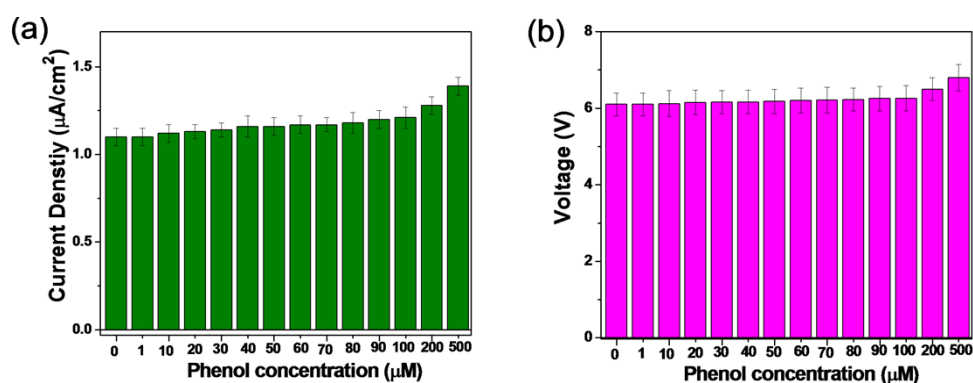
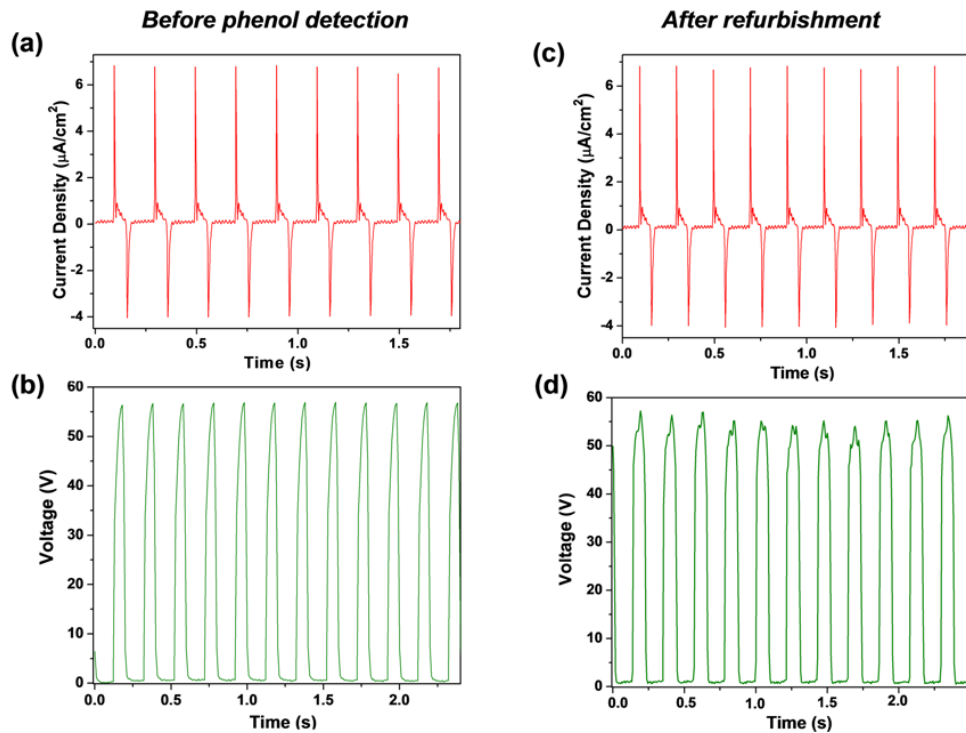
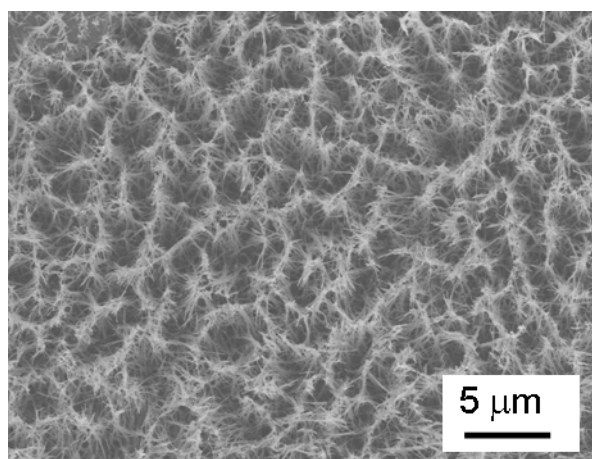


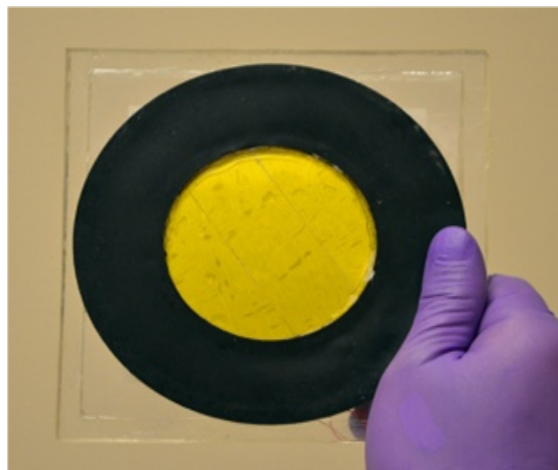
Fig. S4. Dependence of the current (a) and voltage (b) output on the phenol concentrations for the devices without  $\beta$ -cyclodextrin surface modification.



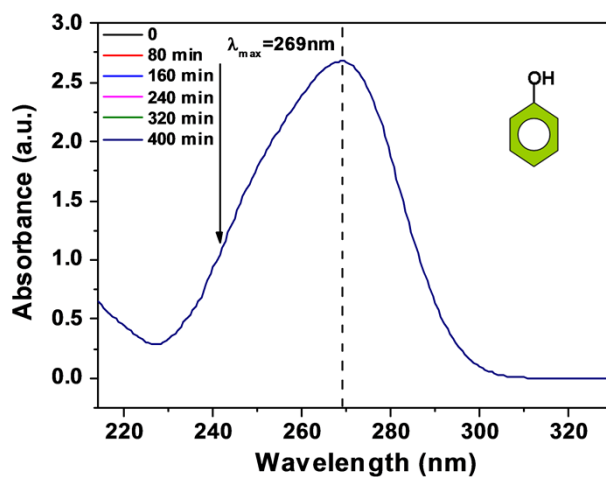
**Fig. S5.** The measured current (a) and voltage (b) of the as-fabricated  $\beta$ -CD enhanced triboelectrification based nanosensor for phenol detection. The measured current (c) and voltage (d) of the refurbished  $\beta$ -CD enhanced triboelectrification based nanosensor by rinsing with 20 ml ethyl alcohol after the usage for phenol detection. The power output performance shows no observable output degradation after refurbishment, which proves a good reusability of the device for phenol detection.



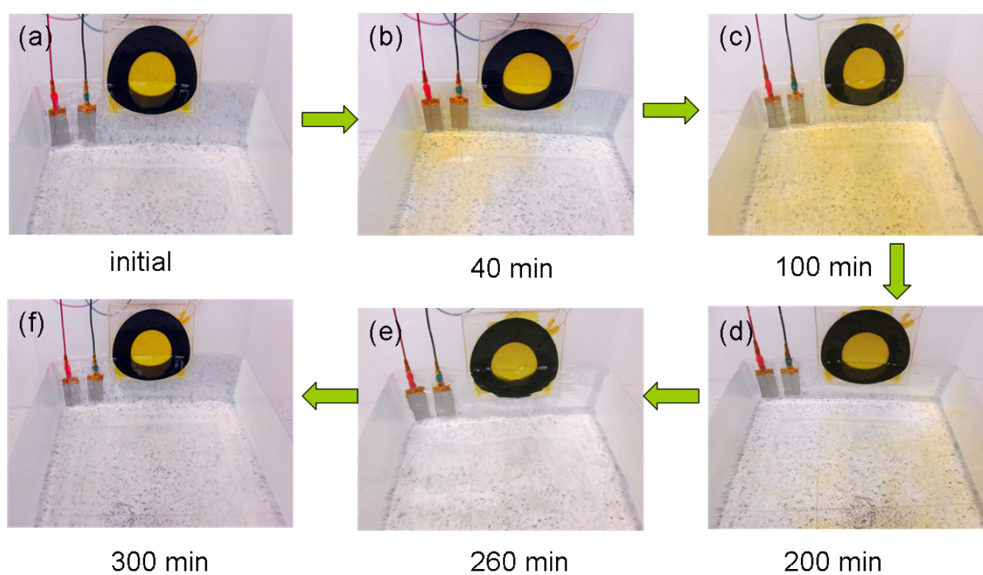
**Fig. S6.** A SEM image of refurbished  $\text{TiO}_2$  nanowires. It proves a good reusability of the device for phenol detection.



**Fig. S7.** A photograph of the as-fabricated  $\beta$ -CD enhanced triboelectrification for self-powered phenol degradation by using kinetic impact energy from water waves. The scale bar is 3 cm.



**Fig. S8.** UV-Visible absorption spectra of the phenol in the wastewater with increasing of the time without triboelectrification or external power sources. It is proved that the phenol can not degrade itself over time without external electricity.



**Fig. S9.** Demonstration of the color changes in the phenol solution from colorless (initial) to yellow (40-260min), and lastly to colorless (300min). The benzoquinone compounds were generated in the oxidation process as intermediates which turned the solution from colorless to yellow. The intermediates were mineralized into  $\text{CO}_2$  and  $\text{H}_2\text{O}$ , and finally the solution became colorless again.