Electronic Supplementary Information

An underwater, self-sensing, conductive composite coating with controllable wettability and adhesion behavior

Guomin Ding, Weicheng Jiao, Rongguo Wang, Zhenming Chu and Yifan Huang*

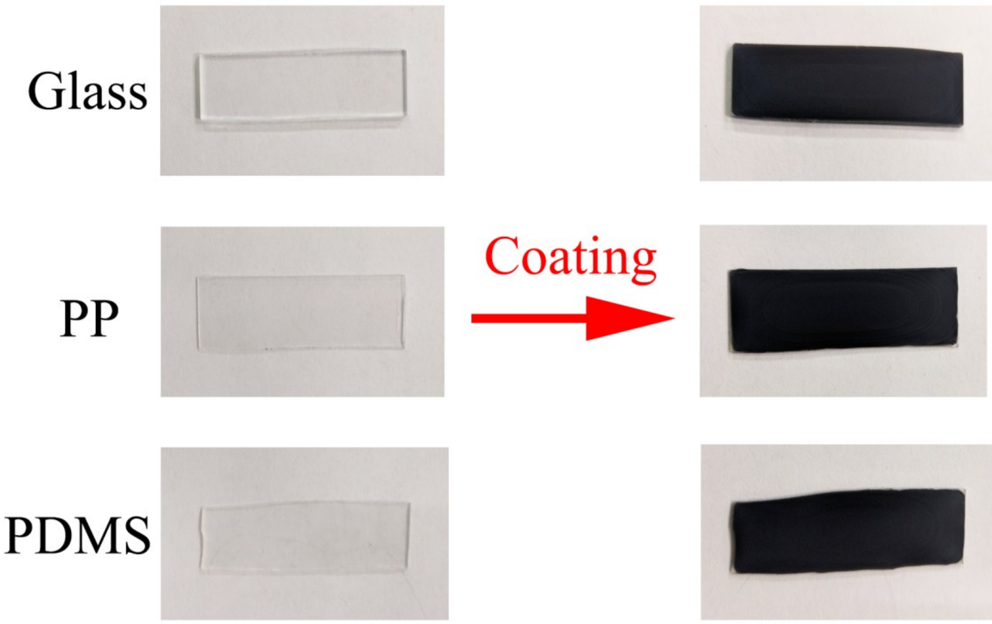


Fig. S1 The photographs of ODA/cCNT-0.5 on different substrates.

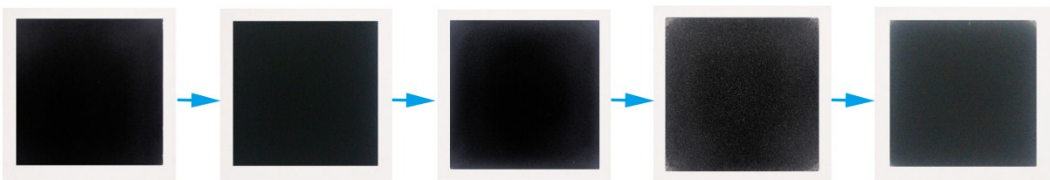


Fig. S2 The photographs of cCNT coating and ODA/cCNTs, which indicate the color of coatings becomes light with increase of ODA.

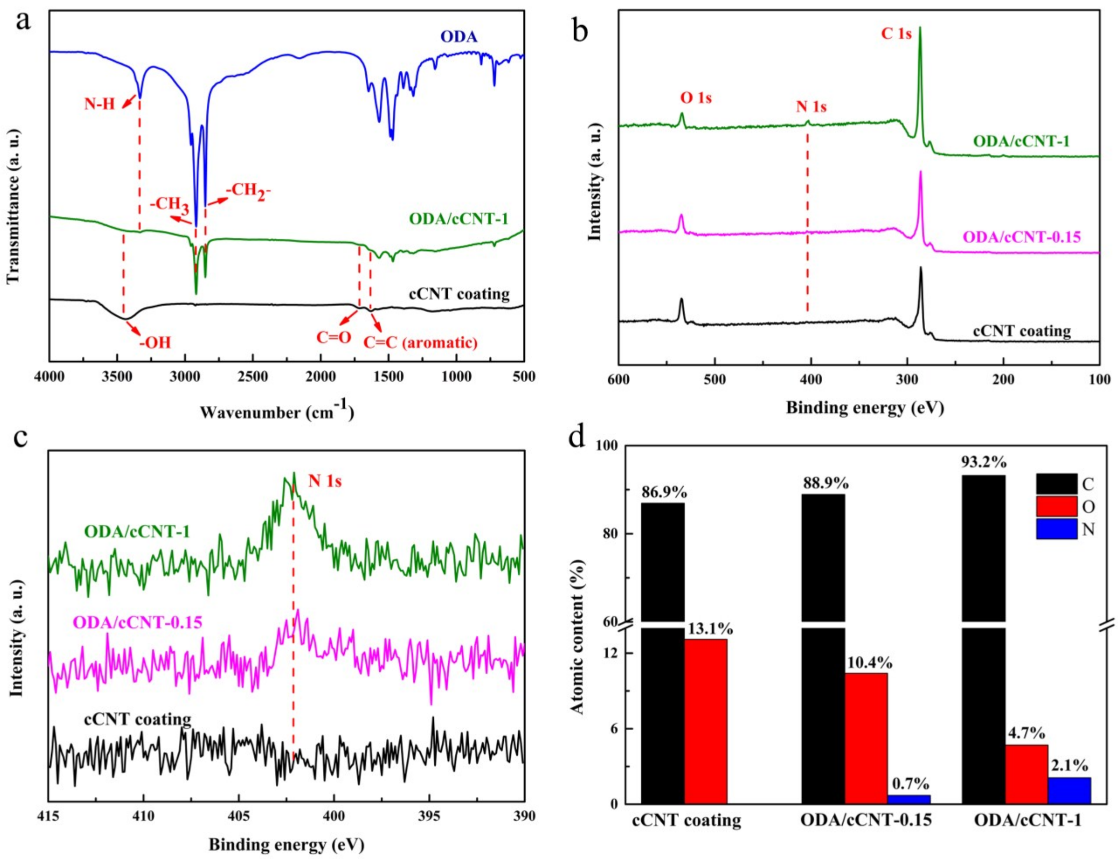


Fig. S3 (a) FTIR spectra of cCNT coating, ODA/cCNT-1 and ODA. (b) Survey scan of XPS spectra of cCNT coating, ODA/cCNT-0.15 and ODA/cCNT-1. (c) N1s spectra of cCNT coating, ODA/cCNT-0.15 and ODA/cCNT-1. (d) The atomic content of cCNT coating, ODA/cCNT-0.15 and ODA/cCNT-1.

The chemical structure of different coatings was characterized by FTIR spectra (Fig. S3a). As shown in the spectrum of ODA, the peaks at 3330 cm^{-1}, 2920 cm^{-1} and 2852 cm^{-1} are assigned to the stretching vibrations of N-H, $-CH_3$ and $-CH_2$ respectively, which are characteristic peaks of ODA.[1, 2] For cCNT coating, the broad peaks at 3450 cm^{-1} (corresponded to O-H stretching vibration) and 1720 cm^{-1} (corresponded to C=O stretching vibration) indicate the existence of carboxyl groups.[3, 4] Besides, The peak at 1627 cm^{-1} is associated with aromatic C=C vibrations of graphitic domains.[5] As a composite, ODA/cCNT-1 has a hybrid spectrum, which possesses characteristic peaks of above both. However, compared with the peak intensity ratio of N-H to $–CH_3$ in ODA (0.26), that in ODA/cCNT-1 decreases to 0.17. This phenomenon indicates that the amino groups of parts of ODA has combined with carboxyl group in cCNTs.[6] So cCNTs have been modified successfully by ODA. Besides, the chemical state of

ODA/cCNTs surfaces was tested by XPS spectra. As shown in Fig. S3b, the main elements of cCNT coating are C and O. When ODA is introduced, the new peak of N 1s arises in the spectrum of ODA/cCNT-0.15, which demonstrates that ODA exists on the surface. This change is also proved by the N 1s spectra of ODA/cCNTs (Fig. S3c). Besides, as ODA increases further, both the peaks of N 1s and C 1s become strong. This indicates the content of ODA on the surface rises, which brings lots of C and N atoms. The specific atomic content in different ODA/cCNTs is shown in Fig. S3d. The above results confirm that ODA has changed the chemical structure of ODA/cCNT surface.

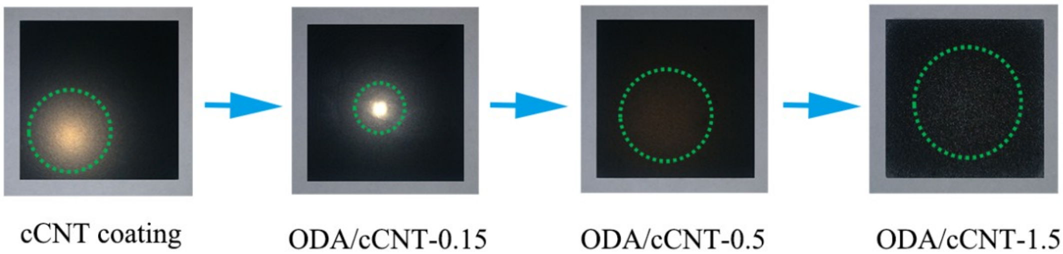
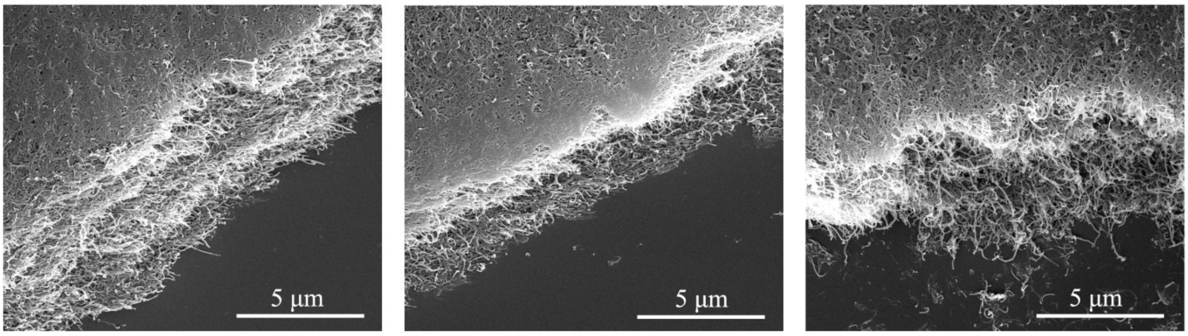


Fig.S4 The photographs of reflection for light on the different coating surface.

The roughness of the coatings surfaces showed a visual change with increase of ODA. In order to highlight the difference, a same beam of light was shined into coatings, and the reflex phenomenon of each surface was observed. Photograph in Fig. S4 shows that cCNT coating surface can reflect light, and a bright area is generated. Furthermore, ODA/cCNT-0.15 shows a typical mirror reflection to form a brighter spot, which indicates that it has a more flat surface. However, as the content of ODA increases, the bright spot disappears gradually. The diffuse reflection for light, which is feature of rough surface, becomes major form on the surface of ODA/cCNT-0.5 and ODA/cCNT-1.5. This phenomenon demonstrates that the surfaces get rough with increase of ODA.



cCNT coating ODA/cCNT-0.15 ODA/cCNT-1.5

Fig. S5 Ordinal SEM images of the inner part of cCNT coating, ODA/cCNT-0.15 and ODA/cCNT-1.5, which were prepared using corresponding solution with the same volume. The coatings were scratched by a needle.

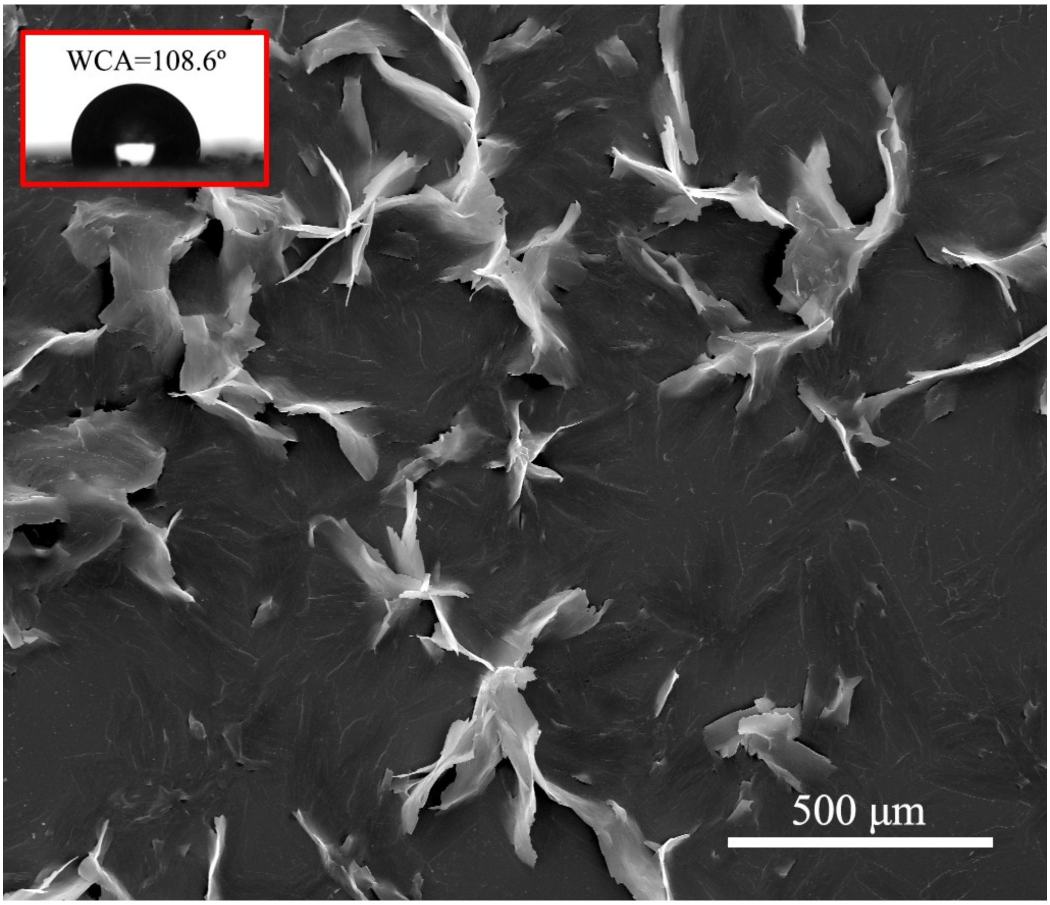


Fig. S6 SEM image of ODA coating and the image of a water drop on its surface.

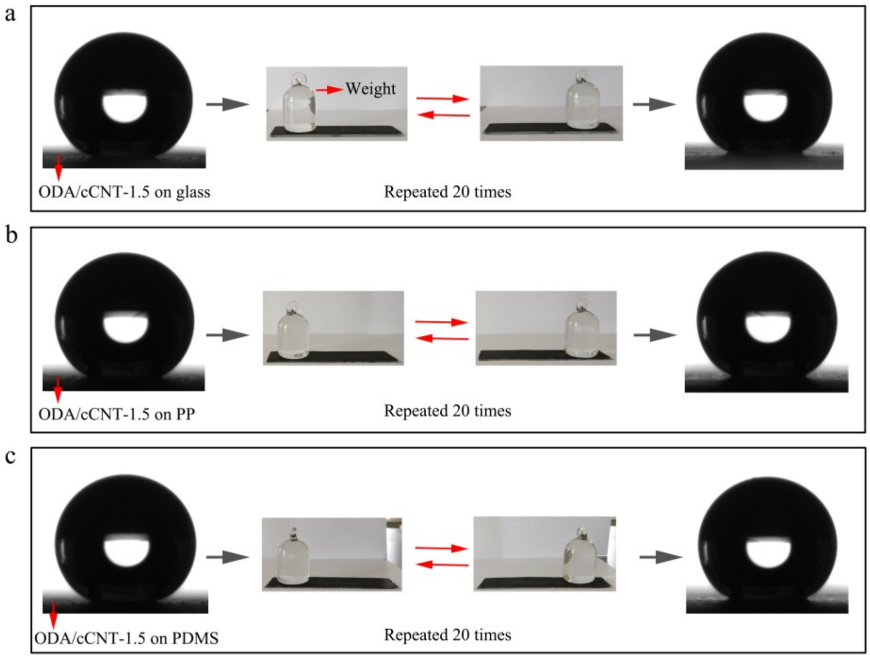


Fig. S7 (a-c) The abrasion test by repeatedly dragging a weight on ODA/cCNT-1.5 with galss, PP and PDMS substrate, respectively.

The abrasion resistance of ODA/cCNT-1.5 was tested by dragging a weight (15 g) back and forth on the surface of ODA/cCNT-1.5 with different substrate (Fig. S7). This operation was repeated at least 20 times. After 20 cycles, the ODA/cCNT-1.5 on all substrates was still superhydrophobic and their WCAs were almost unchanged (WCA of ~ 152°, Figure S7). These results indicated that the abrasion resistance of ODA/cCNT-1.5 is good.

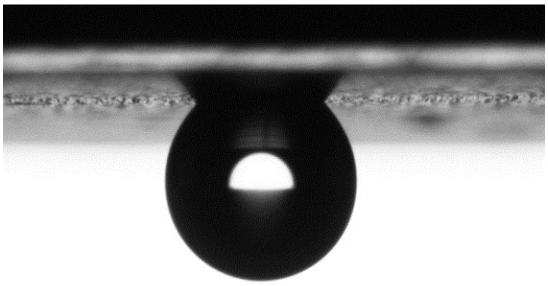


Fig. S8 The shape of a water drop (4 μL) on ODA/cCNT-0.5 when it was turned to 180°.

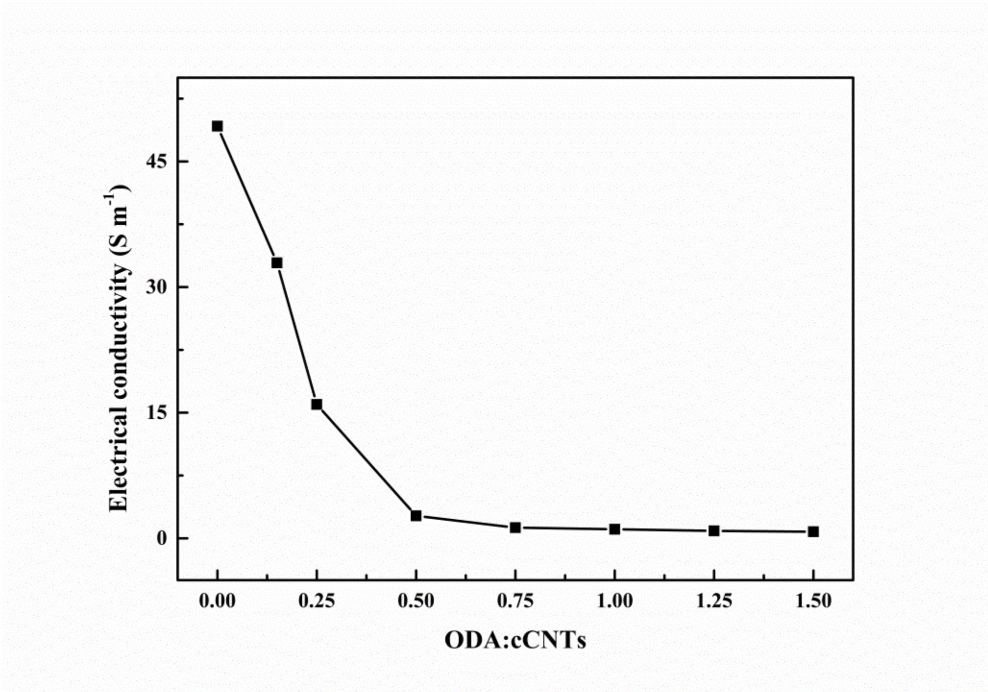


Fig. S9 The change of electrical conductivity of ODA/cCNTs with the increase of ODA:cCNTs.

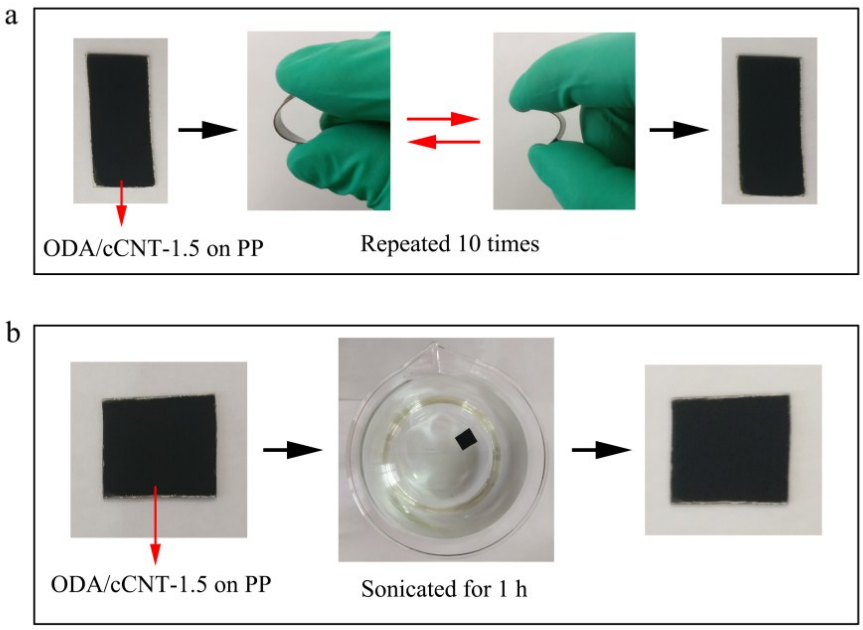


Fig. S10 (a) Photographs of ODA/cCNT-1.5 on PP substrate before and after being bent 10 times. (b) Photographs of ODA/cCNT-1.5 on PP substrate before and after being sonicated for 1 h in water.

The combination performance between the ODA/cCNT-1.5 and the PP substrate was investigated by repeatedly bending the PP plate with ODA/cCNT-1.5. The results showed even after being bent 10 times, the ODA/cCNT-1.5 was still attached firmly to the PP substrate (Fig. S10a). The ultrasonic bath (480 W, 40 kHz) for ODA/cCNT-1.5 on PP plate was also adopted to characterize the adhesion strength. The photographs demonstrated that after being sonicated for 1h, the ODA/cCNT-1.5 coating had no change, and it couldn't fall off from substrate (Fig. S10b). These indicated a strong combination between the ODA/cCNT-1.5 and PP substrate.

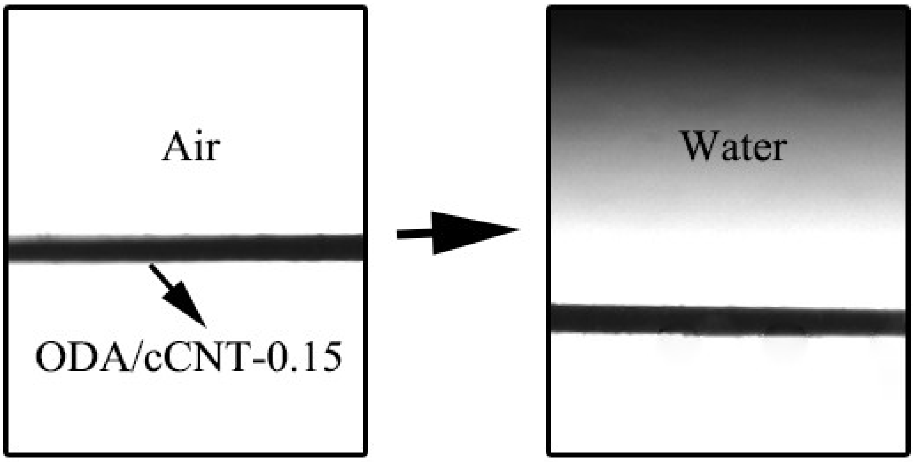


Fig. S11 The images of ODA/cCNT-0.15 in the air and water.

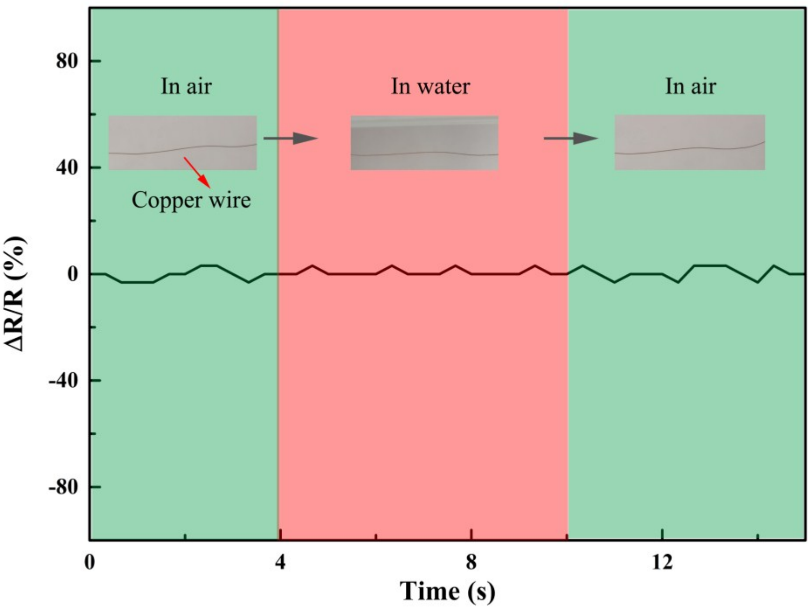


Fig. S12 The change of ΔR/R of copper wire during immersion process. Insets are the photographs of copper wire in the water and air.

Notes and references

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