Flexible organic electrodes built using water-processed silver nanowires

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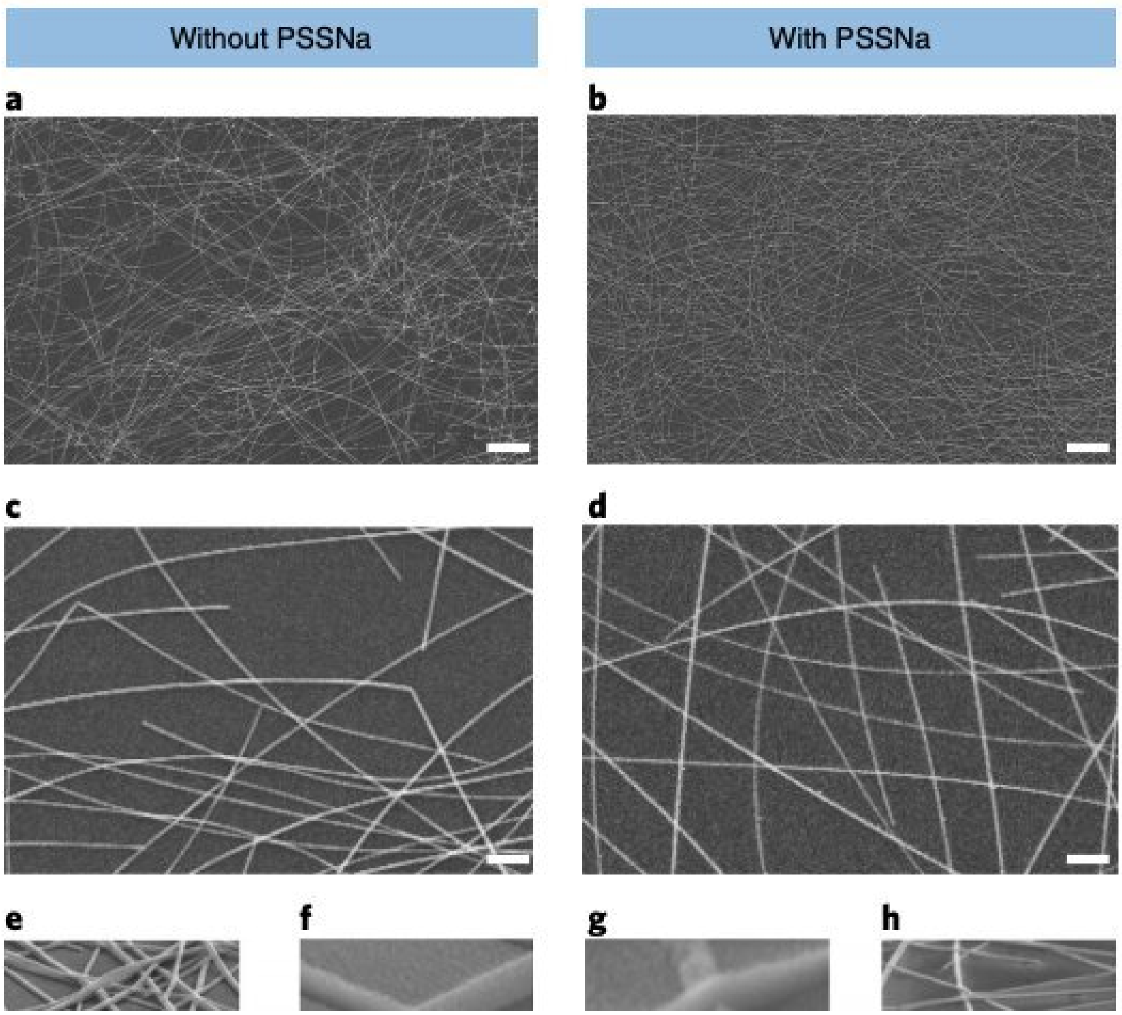

SEM images of the flexible AgNEs electrodes. Credit: Sun et al.

Organic electronic devices, which are made of small molecules or polymers (i.e., substances composed primarily or completely of similar units bound together) are known to have several advantageous properties. In fact, organic electronics have relatively low production costs, they are easy to integrate with other systems and they enable good device flexibility.

Despite their advantages, most organic optoelectronics devices do not perform as well as devices built on rigid substrates. This is primarily due to the lack of existing flexible electrodes that can simultaneously provide low resistance, high transparency and smooth surfaces.

With this in mind, researchers at Nankai University in China have recently set out to create new organic electrodes for flexible photovoltaics, devices that can be used to capture sunlight and convert it into electricity. The electrodes they developed, presented in a paper published in *Nature Electronics*, were built using water-processed silver nanowires and a polyelectrolyte.

A polyelectrolyte is a polymer that has several ionizable groups along its constituent molecules. Polyelectrolytes are widely used for applications including thickening agents in food and in water softeners.

The flexible transparent electrodes (FTEs) presented by the researchers at Nankai University were fabricated via the water-dispersed homogeneous suspension of silver nanowires (AgNWs) using poly(sodium 4-styrensulfonate) (PSSNa) as a polyelectrolyte. The strategy they used to build the electrodes leverages ionic electrostatic charge repulsion among the silver nanowires, which is due to specific properties of the PSSNa anions.

This results in AgNW suspensions that have stable and homogeneous dispersions, producing FTEs that are smooth and have grid-like patterns.

Interestingly, the same fabrication strategy could also be used to create flexible electrodes based on other conducting filler materials (e.g., metals or nanostructured carbon).

"Due to ionic electrostatic charge repulsion, the nanowires form grid-like structures in a single step, leading to smooth, flexible electrodes that have a sheet resistance of around $10\Omega^{-1}$ and a transmittance of around 92 percent (excluding the substrate)," the researchers explained in their paper.

In their study, the researchers used the flexible electrodes they developed to create organic photovoltaic devices. They then tested these devices in a series of experiments, achieving very promising results.

"To illustrate the potential of the approach in organic electronics, we use the flexible electrodes to create organic photovoltaic devices," the researchers wrote in their paper. "The devices are tested with different types of donors and acceptors, and exhibit performance comparable to devices based on commercial rigid electrodes. Furthermore, flexible single-junction and tandem devices achieve power conversion efficiencies of 13.1 percent and 16.5 percent, respectively."

In the future, this strategy for fabricating grid-like, smooth and flexible electrodes could open up new, exciting possibilities for the development of organic electronics. In addition to their use in photovoltaic devices, these electrodes could be integrated within light-emitting diodes, transistors or other electronic components.

More information: Yanna Sun et al. Flexible organic photovoltaics based on water-processed silver nanowire electrodes, *Nature Electronics* (2019). DOI: 10.1038/s41928-019-0315-1