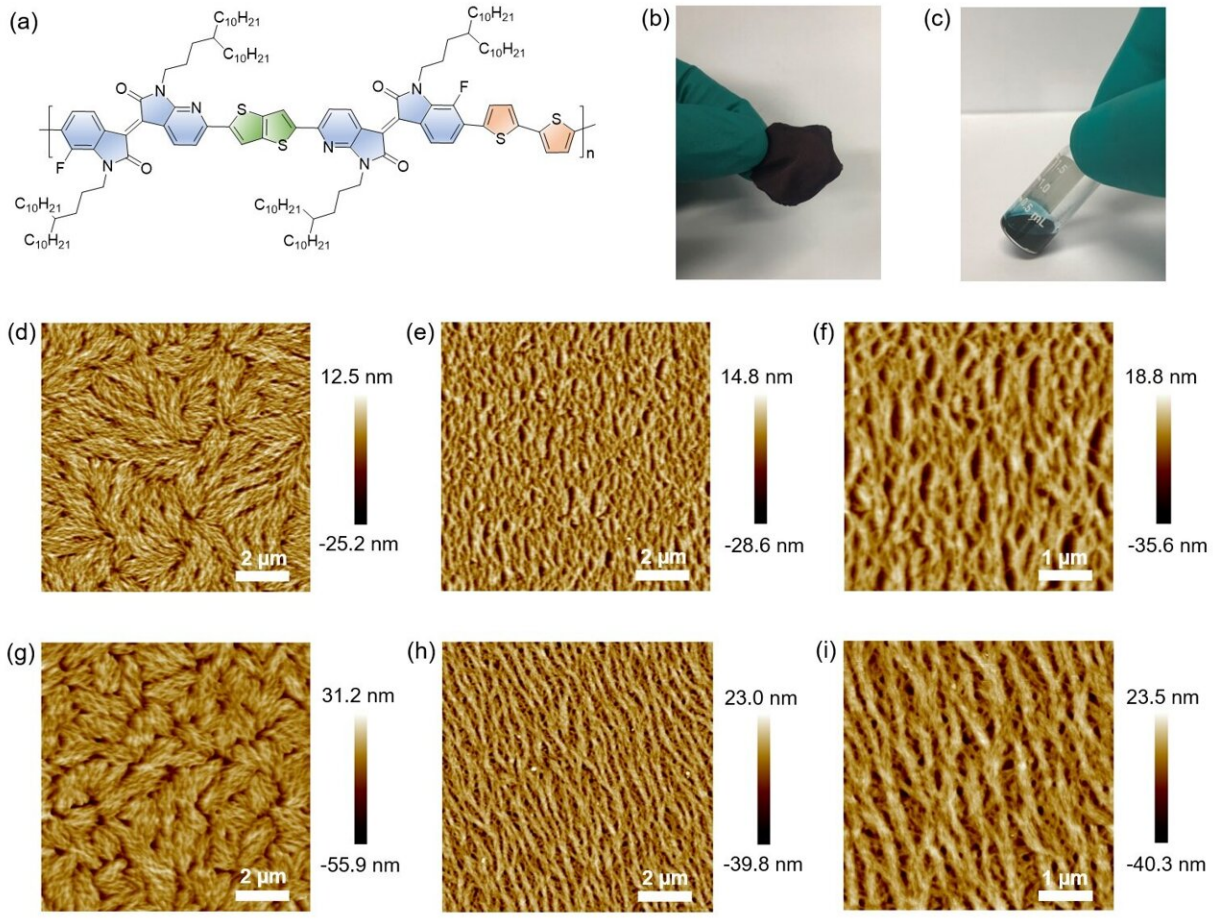
Nonchlorinated solvent-processed high-performance ambipolar transistors

October 19 2021



(a) Molecular structure of PITTI-BT. (b) Photograph of PITTI-BT film. (c) P-xylene solution of PITTI-BT. AFM images of the polymer films prepared by (d,g) on-center and (e,f,h,i) off-center SC methods from (d–f) p-xylene or (g–i) o-dichlorobenzene solution. Photo credit: Jie Yang. Credit: Science China Press

This research is led by Prof. Yunqi Liu (Institute of Chemistry Chinese Academy of Sciences) and Prof. Yunlong Guo (Institute of Chemistry Chinese Academy of Sciences). Ambipolar polymer semiconductors have wide applications in electronic devices such as organic field-effect transistors (OFETs), logic circuits, and organic light-emitting transistors (OLETs). Although some high-performance ambipolar polymers have been developed, their optoelectronic devices are generally processed from toxic chlorinated solvents. To achieve the commercial applications of organic electronic devices, the polymers should be processed from nonchlorinated solvents. However, most of semiconducting polymers are hardly soluble in nonchlorinated solvents.

The team sought to develop high-performance ambipolar polymers that can be processed from nonchlorinated solvents. They thought that decreasing the molecular weights of polymers might be an effective way to improve the solubility of polymers in nonchlorinated solvents. Based on this idea, they synthesized an isoindigo-based polymer (PITTI-BT) by designing a monomer with a large molar mass. The monomer has a large molar mass of 2203 g/mol, which can slow down the polymerization reaction rate and decrease the polymer's molecular weight. As a result, PITTI-BT showed a low M_n of 18.3 kDa and was highly soluble in chlorinated solvent (o-dichlorobenzene) and nonchlorinated solvent (p-xylene).

In addition, in order to improve the performance of OFET devices, they tried to explore the possibility of polymer alignment based on PITTI-BT using a simple off-center spin-coating (SC) method. The UV−vis absorption spectra indicated that PITTI-BT could form pre-aggregation both in p-xylene and o-dichlorobenzene solutions, which was favorable for the formation of aligned polymer films in solid state. As evidenced by atomic force microscopy (AFM), off-center spin-coated films from o-dichlorobenzene and p-xylene solution achieved well-aligned alignment. Finally, the researchers fabricated OFET devices from p-xylene using an

off-center SC method. The devices achieved record ambipolar performance with hole and electron mobilities of 3.06 and 2.81 $cm^2 V^{-1} s^{-1}$, respectively. In contrast, the devices using a traditional on-center SC method only showed hole and electron mobilities of 1.51 and 1.31 $cm^2 V^{-1} s^{-1}$, respectively. The combination of nonchlorinated solvents and good alignment process provides an effective and eco-friendly approach to achieve high-performance ambipolar transistors.

The research was published in *National Science Review*.

More information: Jie Yang et al, A nonchlorinated solvent-processed polymer semiconductor for high-performance ambipolar transistors, *National Science Review* (2021). DOI: 10.1093/nsr/nwab145

Provided by Science China Press