Study contributes to the production of flexible electronic devices

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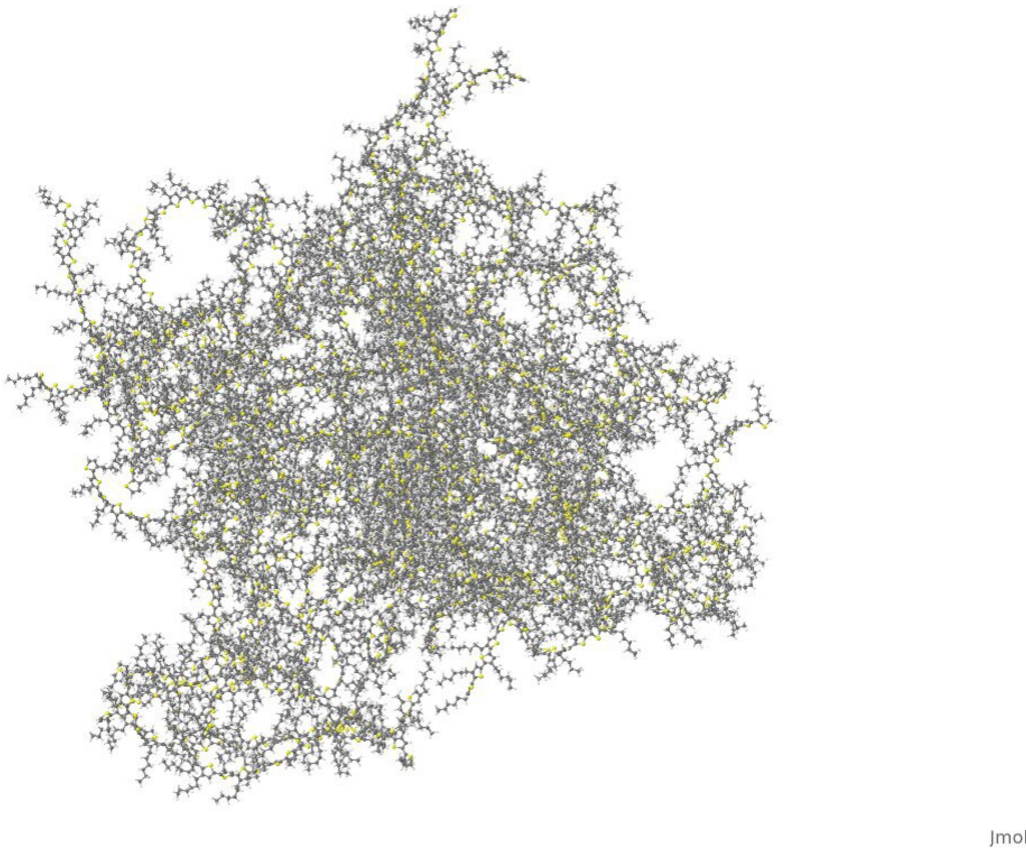

A disordered polythiophene film. Credit: Marília Junqueira Caldas

Flexible electronics is one of the most important trends in technology today. The market is growing so fast that it is expected to double in value in the next decade.

Extremely light and even bendable optoelectronic equipment that supplies, detects and controls light will become commonplace in the near future. A great deal of research is progressing in this direction, as exemplified by a paper recently published in *Scientific Reports*.

The paper describes an experimental and theoretical study conducted by Brazilian and Italian researchers to enhance the optical and electronic properties of polythiophene, an electrically conductive and electroluminescent polymer. Organic, light, flexible and easy to process, it is highly attractive in mechanical terms.

"The configuration of polythiophene processed in the most common way, by spin casting, is so disordered as to impair its optical and electronic performance. In our study, we set out to pattern the material in a more ordered manner and make it more selective in emitting and absorbing light," said Marilia Junqueira Caldas, a full professor at the University of São Paulo's Physics Institute (IF-USP) in Brazil. Caldas participated in the study by contributing to the theoretical framework that described and explained the experimental data.

The pattern she mentioned was obtained via a surprisingly simple stacking arrangement. A droplet of the polymer in solution was deposited on a substrate. As it evaporated, an elastomeric stamp was placed on it to produce a sequence of parallel stripes, which organized the internal structure of the material.

"Patterning made the polymer absorb and emit light in a highly predictable manner, so that stimulated light emission was possible at frequencies not feasible with disordered film. In addition to this gain in selectivity, the resulting device was far lighter than others with a similar function based on stacked layers of several types of semiconductor," Caldas said.

She explained the relationship between selectivity and ordering as follows. "We calculated its molecular dynamics to find out how it behaved in the disordered phase. We obtained a set of tortuous, intertwined and coupled structures. In this situation, an electron shifted from its initial position by light incidence may become misaligned with the hole left in the atom chain and migrate to distant regions in the interior of the material," she said.

"This happens to a large number of electrons, and light absorption and emission are highly disordered as a result. Patterning makes the atom chains almost linear, and electrons and holes are very close together in the same chains. The electrons migrate and then return to their starting point, where they emit and absorb light."

This technique organized the intrinsically disordered material during the process of "growth," and as such, it can be used in a wide range of optoelectronic applications."Our approach demonstrates a viable strategy to direct optical properties through structural control, and the observed optical gain opens up the possibility of using polythiophene nanostructures as building blocks for organic optical amplifiers and active photonic devices," the authors write in the article.

More information: Alberto Portone et al, Tailoring optical properties and stimulated emission in nanostructured polythiophene, *Scientific Reports* (2019). DOI: 10.1038/s41598-019-43719-0

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