Chemists develop a new method for the synthesis of polymer nanoparticles of a given size

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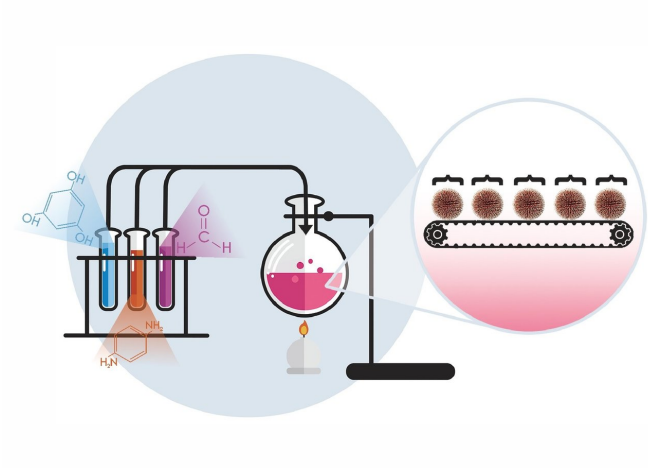

RUDN Chemist have developed a new method for the synthesis of polymer nanoparticles of a given size. Credit: Allen Dressen

A chemist from RUDN created the technology for the synthesis of polymer nanospheres for use in the production of electrochemical devices. The method does not require any surfactants and produces nanoparticles of a predetermined size. The results of the study were published in *Polymer Chemistry*.

Nanoparticles used for industrial applications should be the same in shape and size, regardless of the material they are made of. That is a difficult challenge to achieve both in the laboratory and for industrial production. In some cases, nanoparticles with even a few tens of nanometers difference in size do not perform the required functions. RUDN University's Rafael Luke, together with colleagues from China and Pakistan, proposed a simplified method for creating polymer nanospheres of controlled size.

The new technology is based on the sol-gel process of polymer synthesis. Scientists mix a series of monomers and start hydrolysis and polycondensation reactions. These processes lead to the formation of a sol—a solution of the tiny particles, including nanosized particles of a solid substance or gas bubbles. Upon further processing, the sol either concentrates to the state of a homogeneous gel or exudes the individual nanoparticles (for example, by centrifugation). In order to make the resulting particles homogeneous, it is necessary to apply surfactants to the sol or to use a matrix.

The researchers obtained nanoparticles by synthesizing polybenzoxazine compounds, a group of polymers that can be produced from various monomers under fairly mild conditions. Unlike most of the previous researchers the chemists at RUDN managed to synthesize polybenzoxazine in the form of nanoparticles without using any matrices or surfactants. Chemists have found specific concentrations of the monomers (phloroglucin, para-phenylenediamine, and formaldehyde) dissolved in water and ethanol which, in combination with mild (up to 75 ° C) heating, led to the formation of nanospheres of uniform size. The authors suggest that the effect is achieved due to the use of para-phenylenediamine. It participates in the reaction and acts as a catalyst. Researchers and manufacturers can set the desired size of nanoparticles by varying the concentration of the initial monomers and the ratio in water and ethanol solutions. That is an additional advantage of the new method. In the experiment, section researchers managed to product nanospheres with a diameter of 105, 157 and 186 nm.

Nanoparticles of this type can be used in electrochemistry. Researchers at RUDN carbonized the polymeric nanospheres in a

nitrogen atmosphere at 800 ° C and obtained carbon nanospheres containing nitrogen, which retained the same size and shape. These nanoparticles were used to create electrodes. Carbon nanospheres demonstrated high electrical capacity. In the future, they can be used to create supercapacitors and chemical current sources.

"The traditional approach to the synthesis of such polymers requires the use of surfactants or matrices. They directly control the size of the particles and build the structure of the material," explains Rafael Luka, director of the Molecular Design and Synthesis of Innovative Compounds for Medicine. "Our approach allows you to stop using them. We have already tested one of the possible applications of the obtained nanoparticles. Carbon nanospheres containing nitrogen without additional activation were used as a supercapacitor and demonstrated the potential to be used in the field of energy conversion and storage."

More information: Jianming Zhao et al. Facile surfactant-free synthesis of polybenzoxazine-based polymer and nitrogen-doped carbon nanospheres, *Polymer Chemistry* (2018). DOI: 10.1039/C8PY00911B

Provided by RUDN University