Light and milling balls for greener chemical processes

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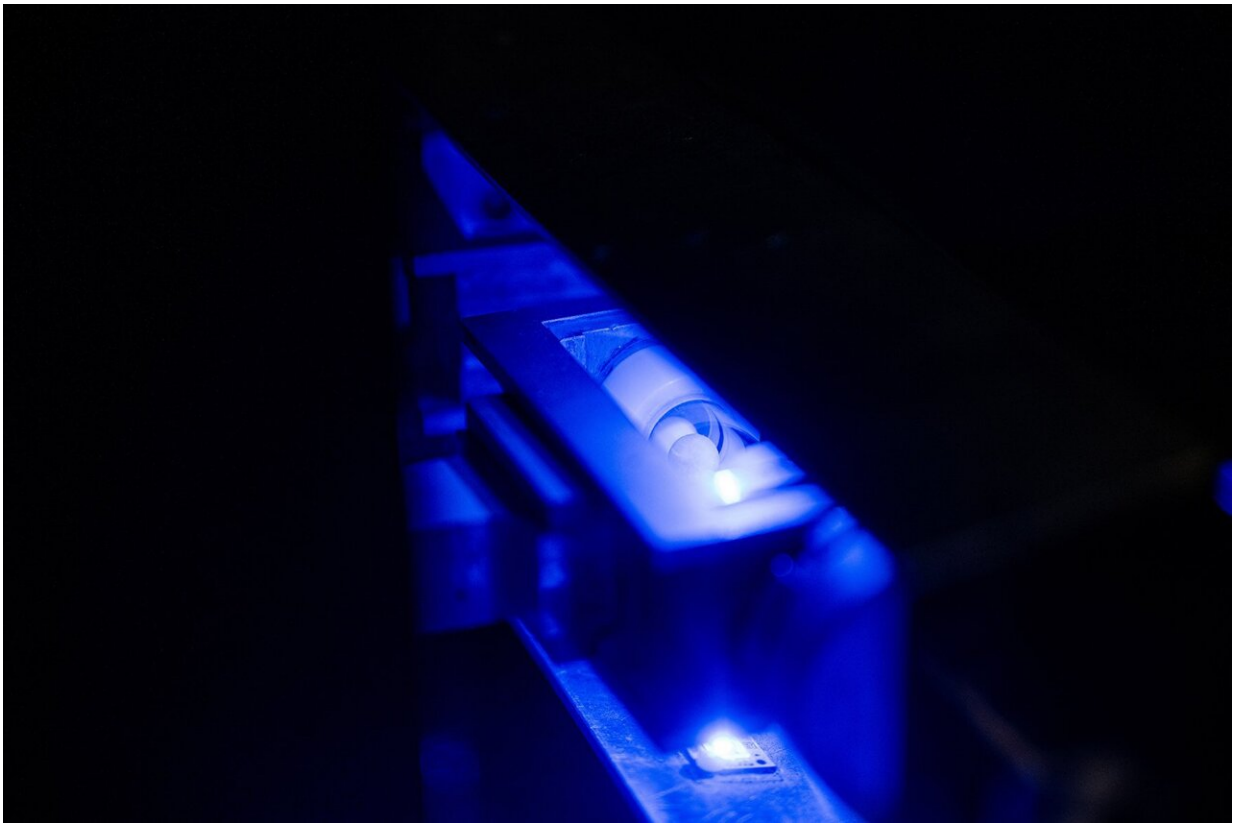

Light and mechanical energy interact in this reactor. Credit: Ruhr University Bochum

Light-driven chemical reactions have usually been conducted with large amounts of solvents that are often toxic. By combining them with

mechanical energy in ball mills, Professor Lars Borchardt's team at the Chair of Inorganic Chemistry I at Ruhr University Bochum, Germany, has succeeded in carrying them out in the solid-state without resorting heavily to solvents.

"This provides a sustainable alternative to established synthesis methods," says Borchardt. The researchers published their findings in the journal *Angewandte Chemie* on February, 24 2023.

Ball mills to replace solvents

Light is considered the ideal driving force of chemical reactions: it's cheap, available in abundance and produces no waste. This is why light-driven, i.e., photochemical reactions, are highly attractive for the production of chemical compounds. However, they are usually performed in huge amounts of solvent, which are often toxic and generate hazardous waste in enormous quantities. Solid-state photochemical reactions without solvents could present an alternative. However, they have not been feasible so far, as they could only be mixed insufficiently and it was therefore not possible to scale them up to relevant quantities.

For photochemical reactions to take place, photons must first reach the starting materials. In order for the reaction to be quick and complete, it's essential for the material to be thoroughly mixed. In conventional reactions, this is ensured by the solvent: it dissolves the substances, makes them mobile and increases mass transport and diffusion. So far, no equivalent method has been available in the solid-state.

The researchers in Bochum used ball mills as reactors. Here, the starting materials are placed in vessels together with milling balls and shaken at high frequencies. This creates high-energy impacts that provide the mechanical energy for the reaction and thoroughly mix the substances.

In a photoreactor that was specially adapted to the mill, the researchers managed to carry out the ball milling process under irradiation. This facilitated photo-mechanochemical synthesis of nanographenes in the solid-state.

"This new process enabled us to carry out specific reactions and synthesize chemical substances in a much more sustainable way," says Lars Borchardt.

"We reduced reaction times by up to 56%, while using 98% less solvent than in equivalent syntheses done with conventional methods. Last but not least, the new photoreactor consumes almost 80% less energy than conventional equipment."

More information: Daniel M. Baier et al, Shedding UV-Light on Mechanochemistry: The Regioselective Solid-State Photochemical Synthesis of Nanographenes, *Angewandte Chemie* (2023). DOI: 10.1002/ange.202218719

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