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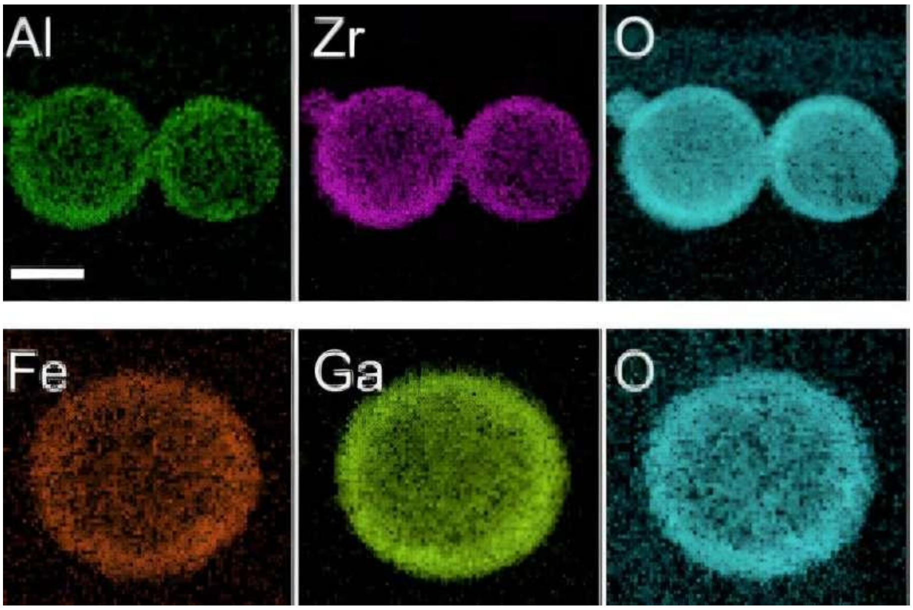
Nanotechnology- To capture methane emissions, scientists create nanoshell catalysts

The unique flame reactor developed in Mark Swihart's lab that creates catalysts in one step. Credit: *Nature Communications* (2024).
A University at Buffalo–led research team is developing new catalysts that aim to turn climate-warming methane emissions into useful commercial products.

The work could impact numerous industries—including natural gas and crude oil production, livestock farming, landfilling and coal mining—where methane is a byproduct. There is an opportunity with methane to make more of an immediate impact in reducing climate-warming emissions. Work is being done on a cost-effective solution to turn this industrial byproduct into valuable goods, such as chemical feedstocks.



Different nanoshells created by the research team. Credit: Shuo Liu et al

Methane is the second most abundant greenhouse gas and the primary component of natural gas. It lasts only a few decades in Earth's atmosphere compared to centuries for carbon dioxide, but methane traps 80 times more heat. For decades, scientists have struggled to develop inexpensive ways to convert methane into useful products without producing carbon dioxide. A possible solution is dry reforming, an industrial process that can convert both methane and carbon dioxide into chemical feedstocks, which are raw materials that manufacturers can use to create or process other products. But dry reforming methane isn't commercially viable because existing nickel-based catalysts stop working when their catalytically active particles become covered with carbon deposits (coking) or combine into larger, less active particles (sintering). Most catalysts also require complex production procedures.

To overcome these issues, the team utilized a unique flame reactor developed in Swihart's lab that creates catalysts in one step. This aerosol-based process allowed the scientists to explore different, nickel-based catalysts, which in this case are tiny spherical particles called nanoshells. The key breakthrough is the flame aerosol synthesis method. It allows us to overcome traditional limitations and create otherwise inaccessible materials with novel properties. The method produced its highest-performing catalysts by what the research team is calling an "encapsulated exosolution" process, in which nickel nanoparticles formed within the pores of an aluminum oxide shell rather than on its surface. This phenomenon helps build a more stable material that, in turn, creates a more durable catalyst.

In experiments, the team reported that, over the course of 640 hours at 800°C, the catalysts remained effective by converting 96% of methane and carbon dioxide into desired products. The results, the team says, dramatically outperform conventional catalysts. The production method suggests a way forward not only to improved catalysts, but for other fields in which new materials are needed. This includes drug delivery, sensing and detection, energy storage and conversion, and coatings and surface modifiers. (Source: Shuo Liu et al, Challenging thermodynamics-- nano-ceramic, *Nature Communications* (2024).