



# Researchers develop an energy efficient, reusable, and versatile catalytic system using abundant cobalt

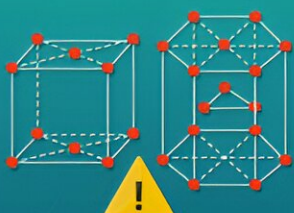
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## Towards Reusable and Highly Selective Cobalt Catalysts

Cobalt nanoparticles (Co NPs) serve as powerful catalysts for hydrogenation processes, which are widely used in the chemical industry

However, our understanding of how the crystal phase of Co affects catalysis is limited because synthesizing Co-NPs with specific phases is difficult




### Preparing phase-controlled Co NPs for selective hydrogenation

**Hydrosilane-assisted method**

$\text{Co}^{2+} + \text{C}_6\text{H}_5\text{SiH}_3$


Additive selection

Use of 1,3-butanediol




Face-centered cubic (fcc) Co NPs


Use of propylene glycol





Hexagonal close-packed (hcp) Co NPs

**Hcp Co NPs exhibited exceptional catalytic performance for nitrile hydrogenation**



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High selectivity (97% yield) for benzyl amine production from benzonitrile
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Very mild reaction conditions and no ammonia addition required
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Novel mechanistic insights into Co-based catalysts

This work will help scientists design better Co-based catalysts for the sustainable synthesis of industrial chemicals

Tuning the Selectivity of Catalytic Nitrile Hydrogenation with Phase-Controlled Co Nanoparticles Prepared by Hydrosilane-Assisted Method  
 Jiang et al. (2024) | *Journal of the American Chemical Society* | 10.1021/jacs.4c04780



Credit: *Journal of the American Chemical Society* (2024). DOI: 10.1021/jacs.4c04780

Controlling the crystal phase of cobalt nanoparticles leads to exceptional catalytic performance in hydrogenation processes, report scientists from Tokyo Tech.

Produced via an innovative hydrosilane-assisted synthesis method, these phase-controlled reusable nanoparticles enable the selective [hydrogenation](#) of various compounds under mild conditions without the use of harmful gases like ammonia. These efforts could lead to more sustainable and efficient catalytic processes across many industrial fields.

Hydrogenation—the chemical reaction of hydrogen gas with another compound—is fundamental in industries such as food, pharmaceuticals, materials, and petrochemicals.

Traditionally, [noble metals](#) like palladium and rhodium serve as catalysts in these reactions. However, these materials are scarce and expensive, and their mining is plagued by [environmental concerns](#). Moreover, they demand highly controlled and energy-intensive conditions to function effectively.

In recent years, cobalt has emerged as a promising alternative to noble metal catalysts for hydrogenation. Cobalt nanoparticles (Co NPs) can catalyze hydrogenation reactions efficiently, requiring [lower temperatures](#) and pressures than noble metal catalysts.

Despite the theoretical significance of the crystal phase of Co NPs in their catalytic performance, studying this has been challenging due to the lack of methods to produce Co NPs with a specific crystal phase of similar size.

Fortunately, a research team from Tokyo Institute of Technology and Osaka Metropolitan University has found a solution to this issue. As reported in their latest study, which was [published](#) in the *Journal of the American Chemical Society*, they devised a new method to selectively produce Co NPs with two very distinct crystal phases in a convenient and consistent way.

"We previously reported that nickel NPs can be readily synthesized by the reduction of nickel complexes in the presence of hydrosilanes through a technique we dubbed the hydrosilane-assisted method," explains Professor Michikazu Hara, who led the study.

"We hypothesized hydrosilanes would act not only as reducing agents for Co cations, but also as ligands on the metal complexes to control the growth of metal particles. Therefore, we attempted to synthesize Co NPs with a controlled crystal phase via the simple addition of appropriate coordination compounds and specific diol solvents."

Through careful testing, the research team found their predictions were right, and the hydrosilane-assisted method could reliably produce two types of Co NPs depending on the reaction conditions: face-centered cubic (fcc) Co NPs and hexagonal close-packed (hcp) Co NPs. They then ran several hydrogenation experiments to explore the differences in catalytic performance between both types of Co NPs.

Interestingly, they observed that hcp-Co NPs were far superior to fcc-Co NPs. In the hydrogenation of benzonitrile into benzyl amine, hcp-Co NPs achieved a much higher selectivity, exhibiting a yield of 97%

compared to fcc-Co NPs' 80%.

Moreover, hydrogenation using hcp-Co NPs required a pressure of roughly half that of fcc-Co NPs, rendering the entire process more energy-efficient. This notable feat is not limited to the production of benzyl amine only, as Hara says, "Worth noting, the proposed Co NP-based catalytic system displayed compatibility with a diverse range of nitriles and carbonyl compounds."

Considering that cobalt is abundant, and the proposed Co NP-base catalyst is reusable and does not require harmful gases such as ammonia, this work could serve as a stepping stone towards more sustainable and cost-effective hydrogenation technologies.

In turn, this may lower the price and environmental impact of many industrial commodities, drugs, and even [food products](#), leading to an overall better future for humanity in multiple ways.

**More information:** He Jiang et al, Tuning the Selectivity of Catalytic Nitrile Hydrogenation with Phase-Controlled Co Nanoparticles Prepared by Hydrosilane-Assisted Method, *Journal of the American Chemical Society* (2024). [DOI: 10.1021/jacs.4c04780](https://doi.org/10.1021/jacs.4c04780)

Provided by Tokyo Institute of Technology

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