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# Multifunctional dendritic mesoporous silica nanospheres loaded with silver nanoparticles as a highly active and recyclable heterogeneous catalyst

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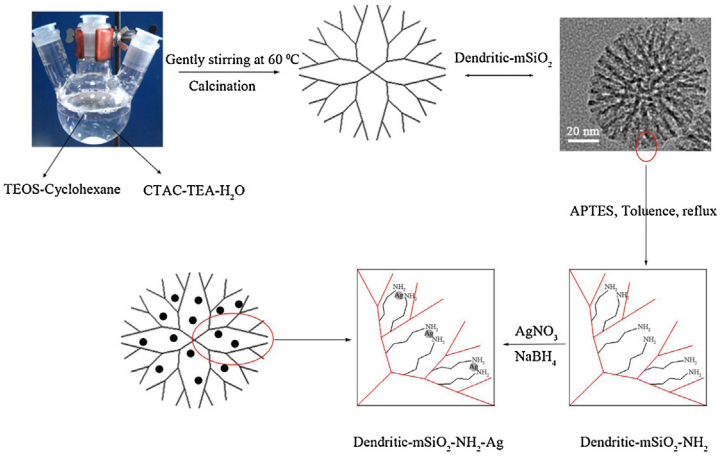
## HIGHLIGHTS

- A multifunctional dendritic silica nanocatalyst was successfully fabricated by an oil–water biphase stratification coating strategy.
- The dendritic silica nanomaterials Dendritic-m$SiO_2$ were chosen as the catalyst's support for the first time.
- The as-synthesized nanocatalyst exhibited excellent catalytic activity and reusability due to easy accessibility of active sites.

## GRAPHICAL ABSTRACT

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## ABSTRACT

In this work, a multifunctional dendritic silica nanocatalyst Dendritic-m$SiO_2$-$NH_2$-Ag with easy accessibility of active sites and high surface area was successfully developed by an oil–water biphase stratification coating strategy, and characterized by transmission electron microscopy, scanning electron microscopy, high-resolution transmission electron microscopy, X-Ray photoelectron spectroscopy, X-ray diffraction, $N_2$ adsorption–desorption, and Fourier transform infrared spectroscopy. The as-synthesized nanocatalyst Dendritic-m$SiO_2$-$NH_2$-Ag showed excellent catalytic activity for the catalytic reduction of 4-nitrophenol and 2-nitroaniline using sodium borohydride in aqueous solution at room temperature owing to easy accessibility of active sites. Additionally, the novel catalyst could be conveniently recovered from the reaction system and recycled for at least five times without obvious loss in activity. These results indicate that the aforementioned approach based on dendritic silica Dendritic-m$SiO_2$ provided a promising platform for the fabrication of noble metal nanocatalysts with easy accessibility and excellent catalytic activity, which could be highly efficient in various catalytic reduction reactions.



## 1. Introduction

Nitrophenol and its derivative are among the most common refractory water pollutants with high toxicity and carcinogenic

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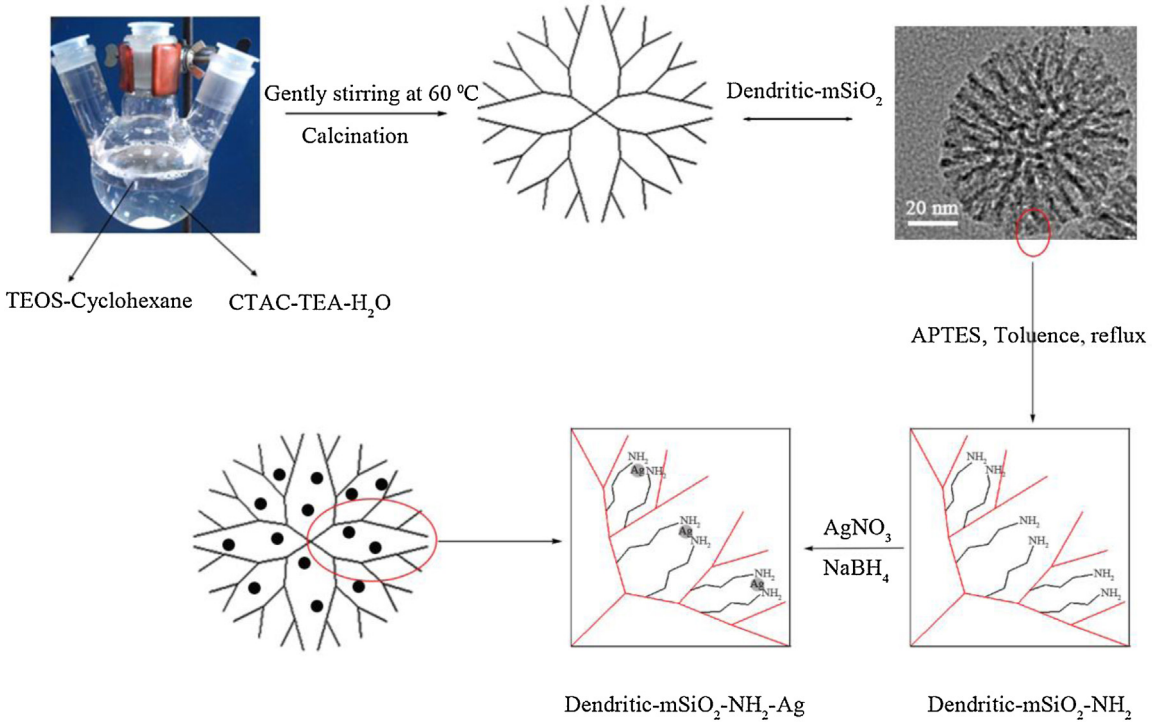
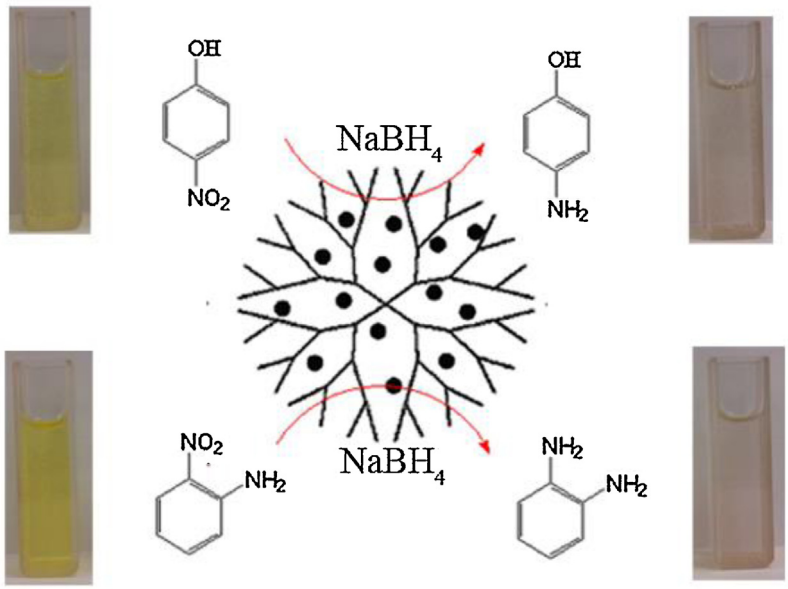



**Scheme 1.** Synthesis procedure for the multifunctional dendritic mesoporous silica nanocatalysts (Dendritic-mSiO$_2$-NH$_2$-Ag) by combining the oil–water bi-phase stratification with a post-synthesis strategy.




**Scheme 2.** The reduction of 4-NP and 2-NA on the surface of Dendritic-mSiO$_2$-NH$_2$-Ag nanocatalyst.

character. In particular, 4-nitrophenol (4-NP) is a toxic industrial organic pollutant and environmentally hazardous material exhibiting high stability and solubility in wastewater, which can cause the harmful effects to animals, agricultural plants and human beings [1]. Moreover, the low concentration of 2-nitroaniline (2-NA) in water is harmful to human health and aquatic life in terms of its mutagenic effects, toxicity, and potential carcinogenic [2,3]. Therefore, the United States Environmental Protection Agency (EPA) has listed 4-NP and 2-NA as toxic wastes and priority hazardous pollutants. Hence, their removal from the environment is a crucial task. Till today, various methods such as microbial degradation, electrocoagulation, electro-Fenton method, photocatalytic degradation, microwave-assisted catalytic oxidation, and electrochemical treatment have been utilized for the disposal of these nitro-compounds [4–6]. However, the catalytic reduction of nitro group to amino group is believed to be the most efficient, eco-friendly, and economical approach to dispose these nitro-compounds [7–10], which can be ascribed to that the reduction products such as 4-aminophenol (4-AP) and *o*-phenylenediamine (*O*-PDA) can be recycled because they are vital category of intermediates for the synthesis of drugs and dyes [2,11,12]. Therefore, it remains a challenge to develop a low-cost and highly effective