Functionalizing Single-Crystals: Nanoparticle Incorporation Inside Gel-Grown Calcite Crystals

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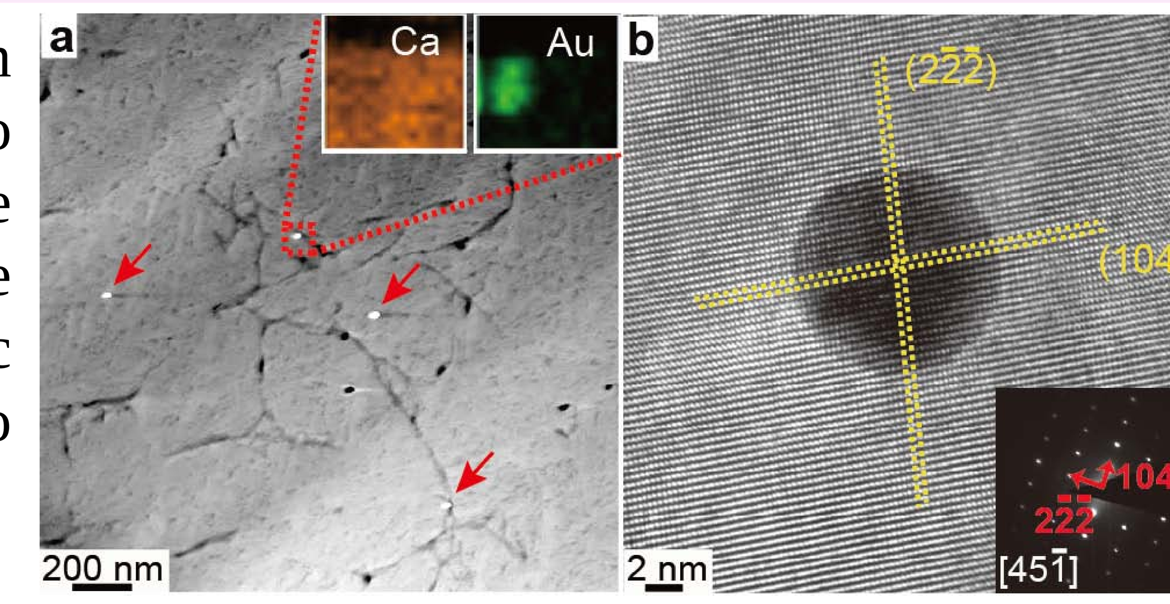
Introduction

Synthetic single-crystals are usually homogeneous solids. Biogenic single-crystals,[1] however, can incorporate biomacromolecules and become inhomogeneous solid so that their properties are also extrinsically regulated by the incorporated materials.[2,3] Here, Au and/or Fe_3O_4 nanoparticles were incorporated, through a gel-grown crystallization method, into calcite single-crystals and, as a result, the intrinsically colorless and diamagnetic calcite single-crystals were turned into colored and paramagnetic solids.[4] As such, our work extends the long-history gel method for crystallization into a platform to functionalize single-crystalline materials to expand their potential application.



Result & Discussion

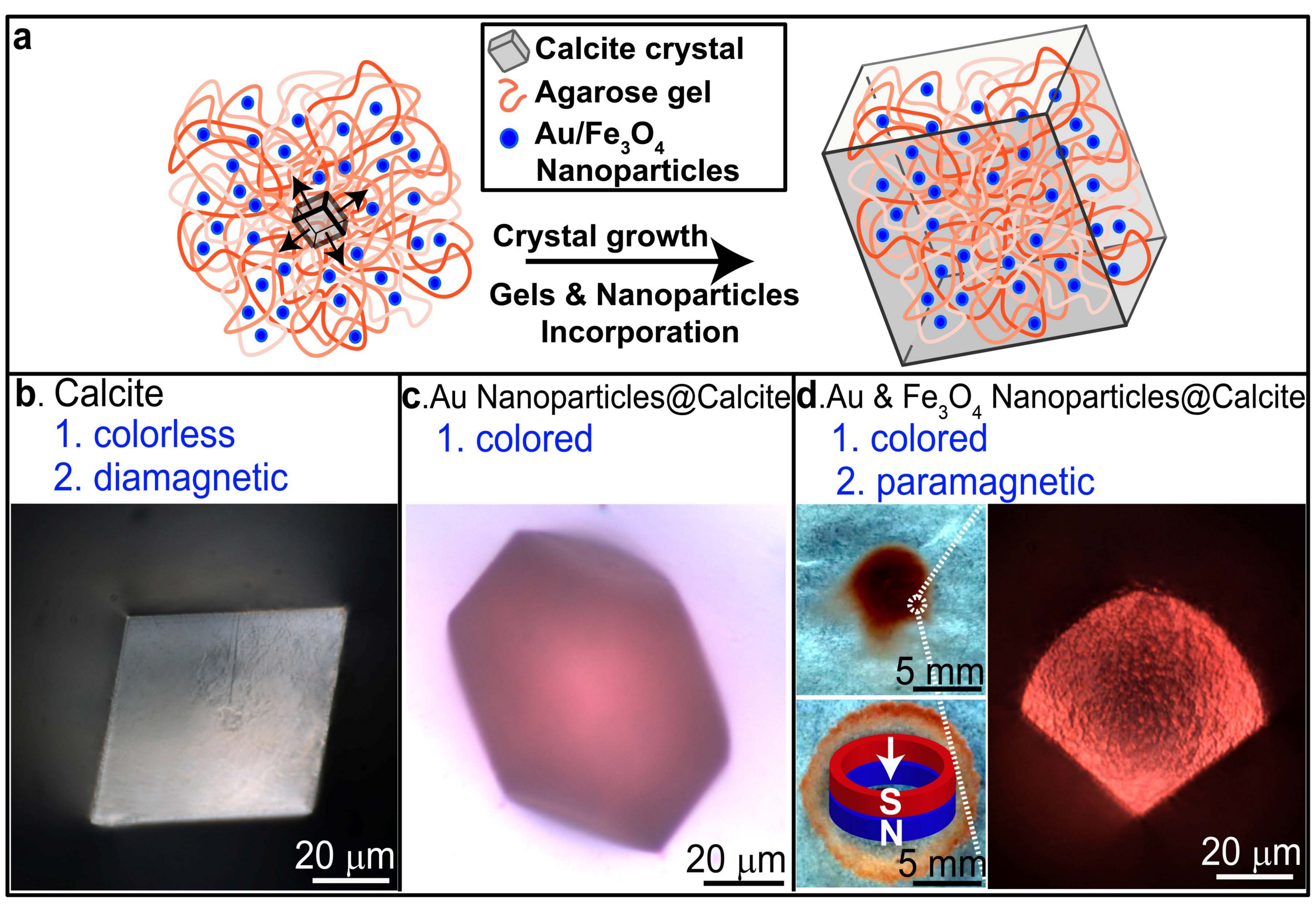


Figure 1. a) Schematic diagram of the crystallization in gel media containing dispersed nanoparticles; b-d) Optical microscopy images of the calcite single-crystals without/with Au and/or Fe_3O_4 nanoparticles incorporated; The two photos in (d) on the left record how the crystals moved outward in a magnetic field.

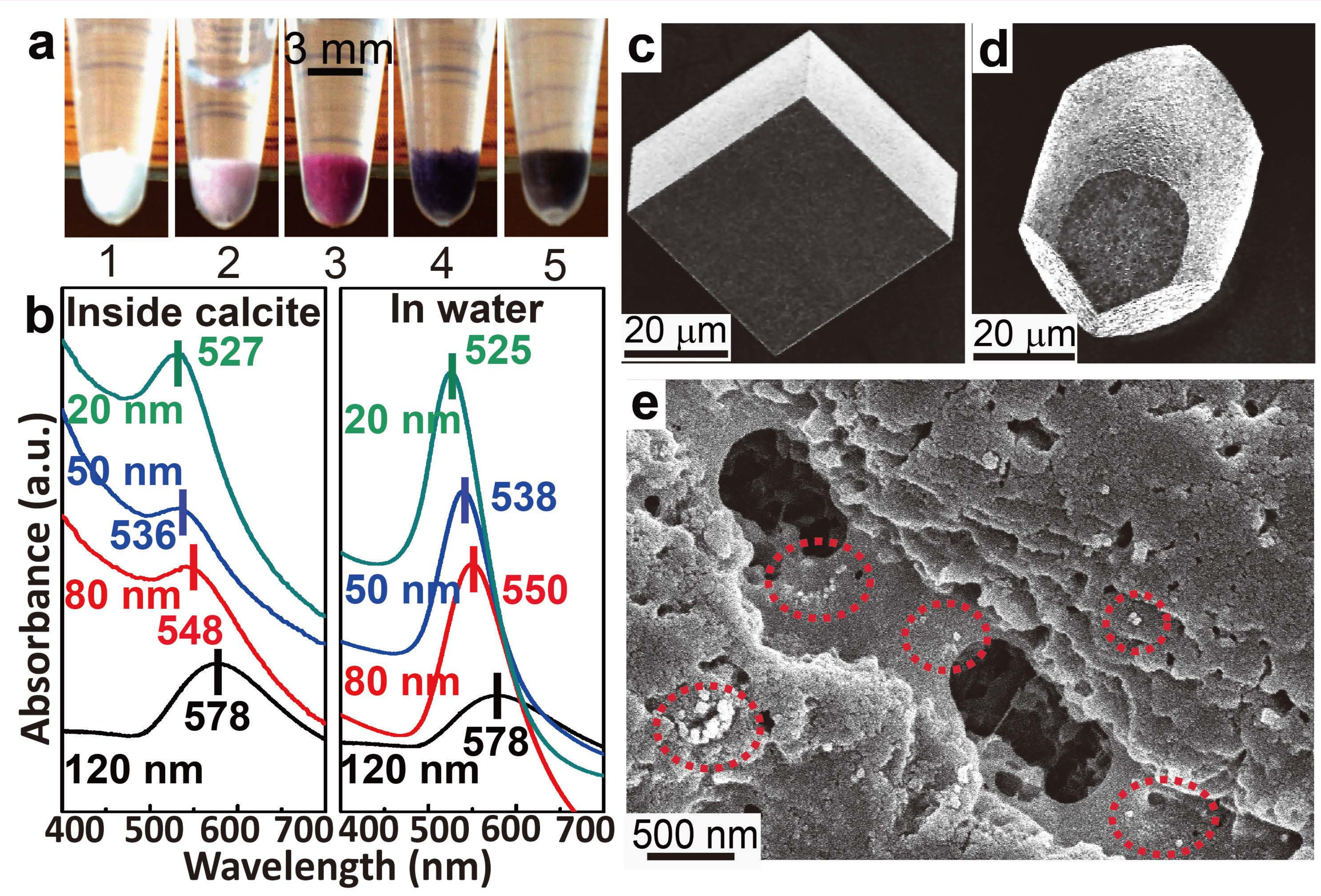


Figure 2. a) Photos of crystals grown in an agarose gel containing Au nanoparticles of varied concentrations and sizes; b) UV-vis diffuse reflectance spectra and UV-vis absorption spectra of Au nanoparticles incorporated inside and dispersed in water; c–e) Representative SEM images of calcite crystals grown in an agarose gel containing Au nanoparticles.

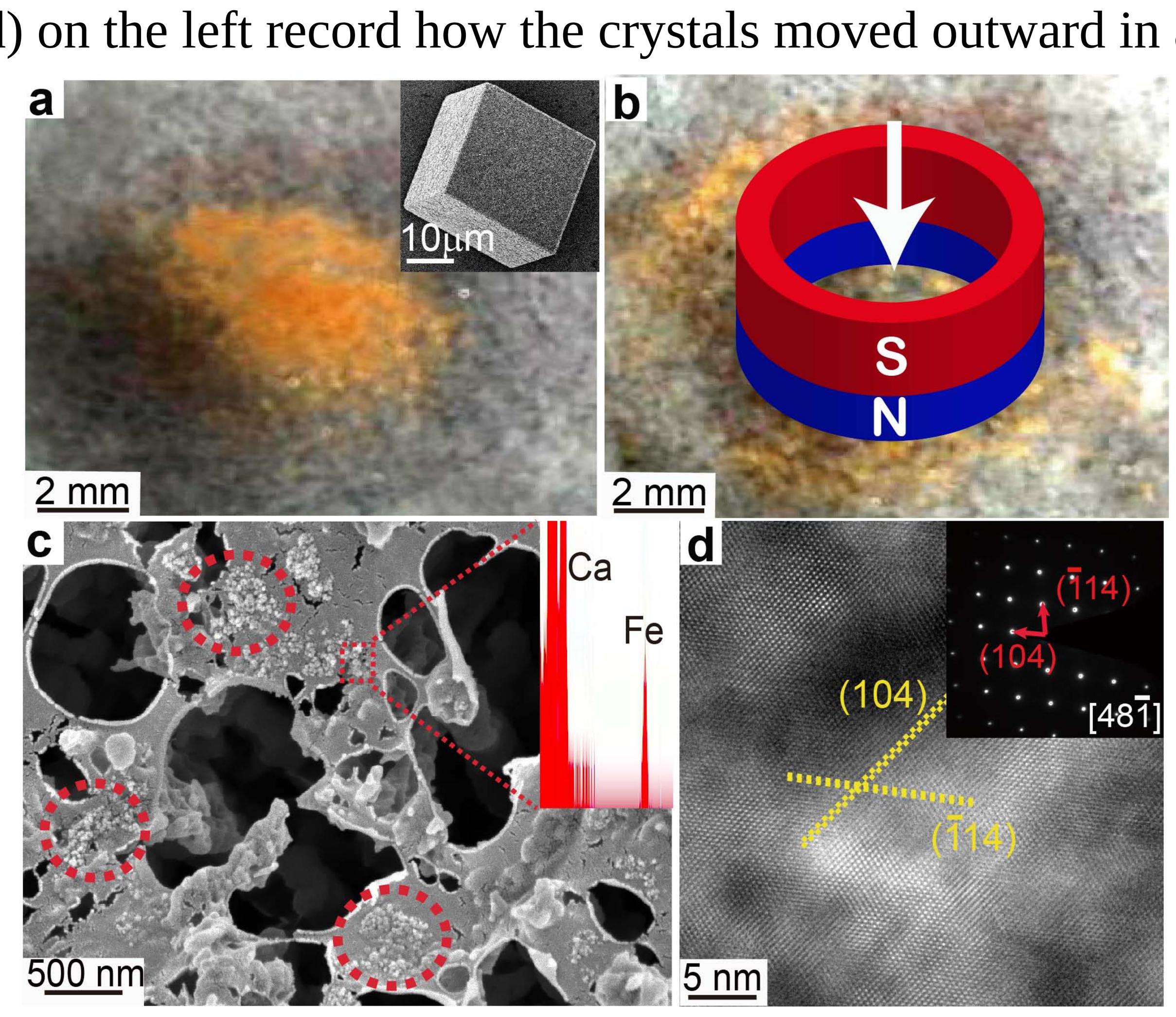
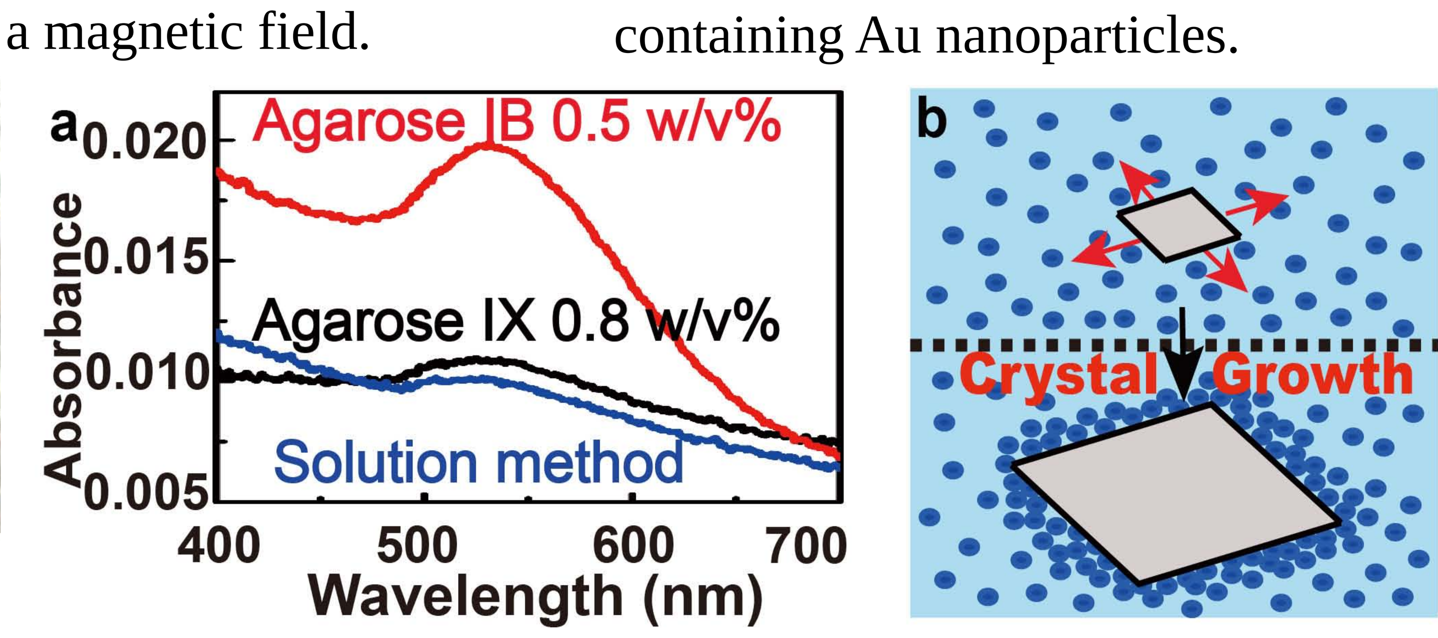


Figure 3. Calcite single-crystals incorporating paramagnetic Fe_3O_4 nanoparticles



Incorporation Mechanism

The growing crystals **incorporate** the gel network and also the trapped nanoparticles. And **nanoparticles** were incorporated only if the **gel polymers** were incorporated.

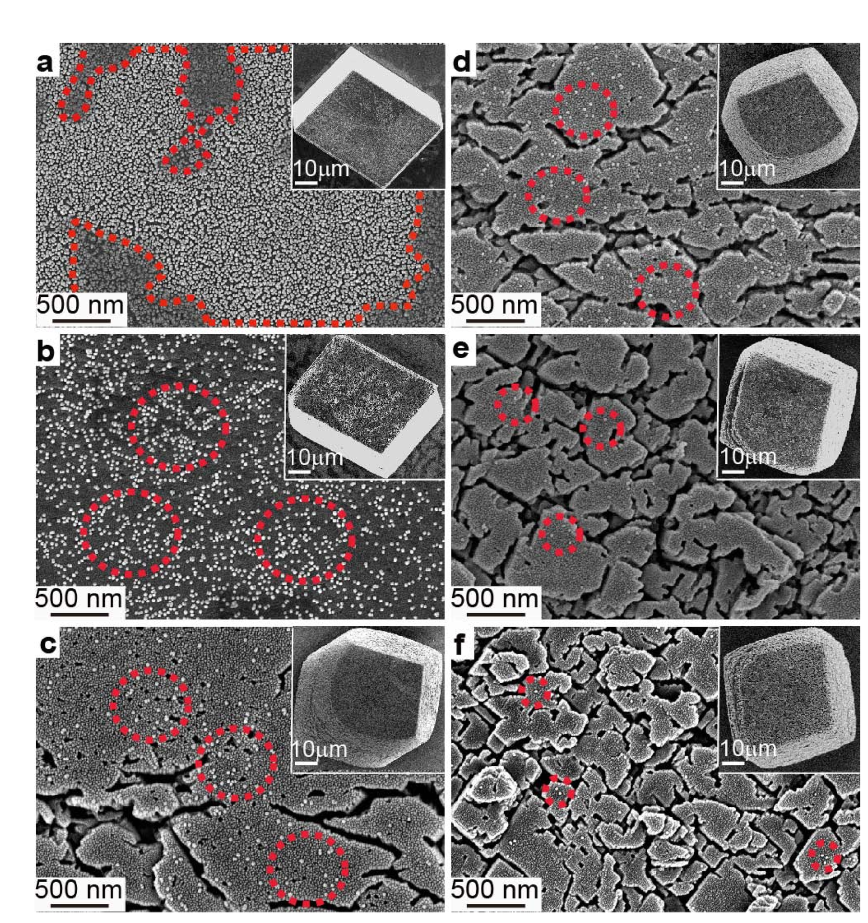


Figure 4. SEM images of Au nanoparticles absorbed on the surfaces of crystals grown in solution or agarose gels with increased concentrations

Conclusion

We have used Au nanoparticles to “dye” the calcite single-crystals and Fe_3O_4 nanoparticles to endow the crystals with paramagnetism. The optical and magnetic functionalization are achieved through nanoparticle incorporation inside the single-crystals. Gel growth media instead of solutions are necessary to induce the nanoparticle incorporations during which crystals incorporate the gel network and also the nanoparticles trapped in the gels. This work creates a novel and facile pathway to design functionalized single-crystalline materials to expand their potential applications.

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Reference

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