Mg nanoplasmonics: Shapes, reactivity, and optical properties

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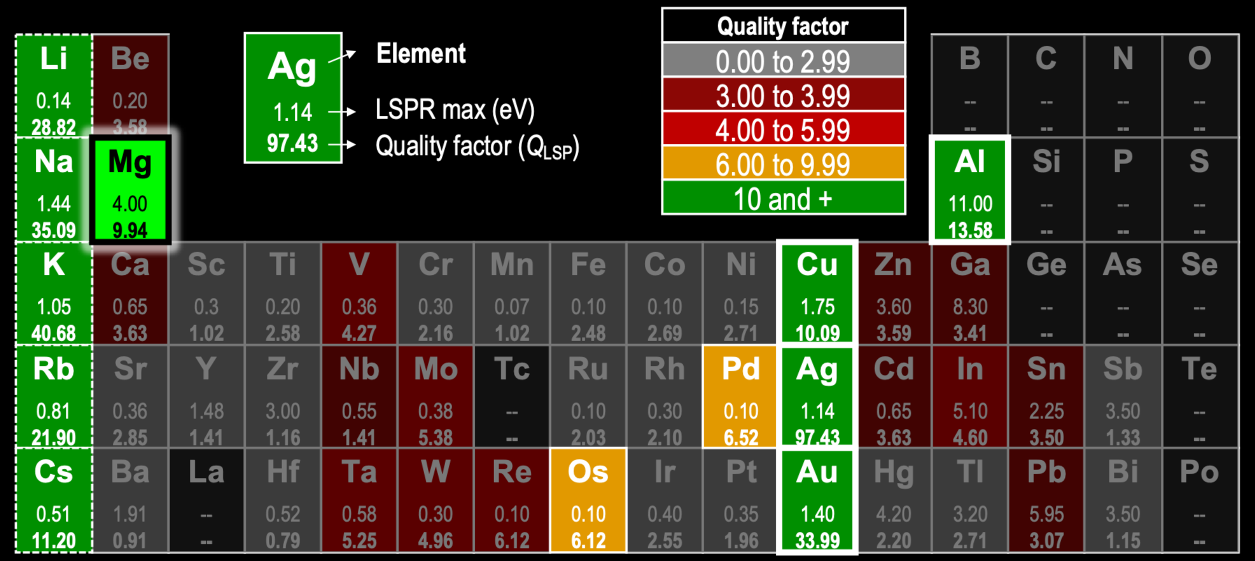
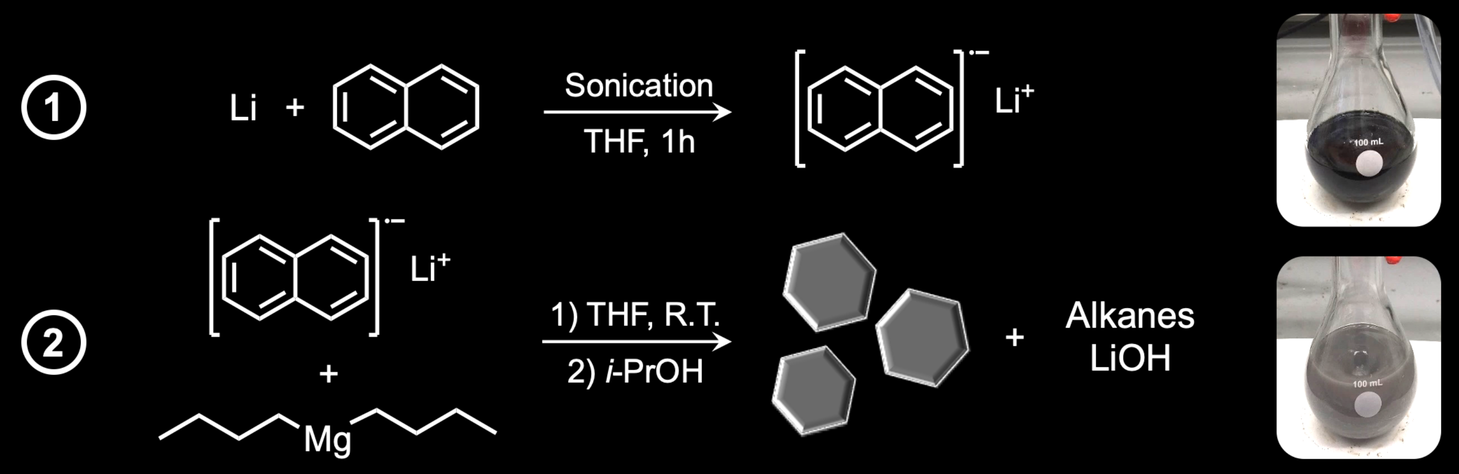
Towards sustainable plasmonics(1)

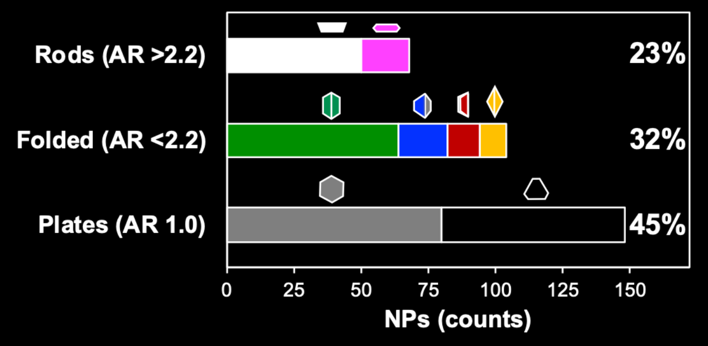


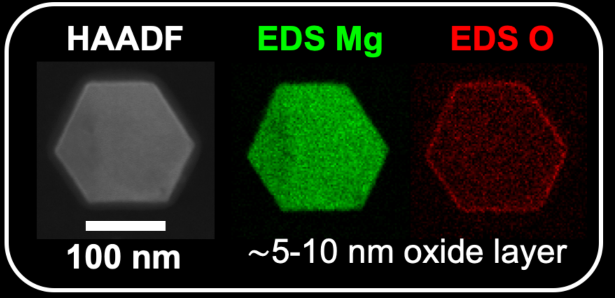
Noble metals have been the gold standards for plasmonic materials over the last millennia; however, the high cost of Ag and Au can be prohibitive in large-scale mainstream applications. **Magnesium** has been predicted to be an alternative offering:

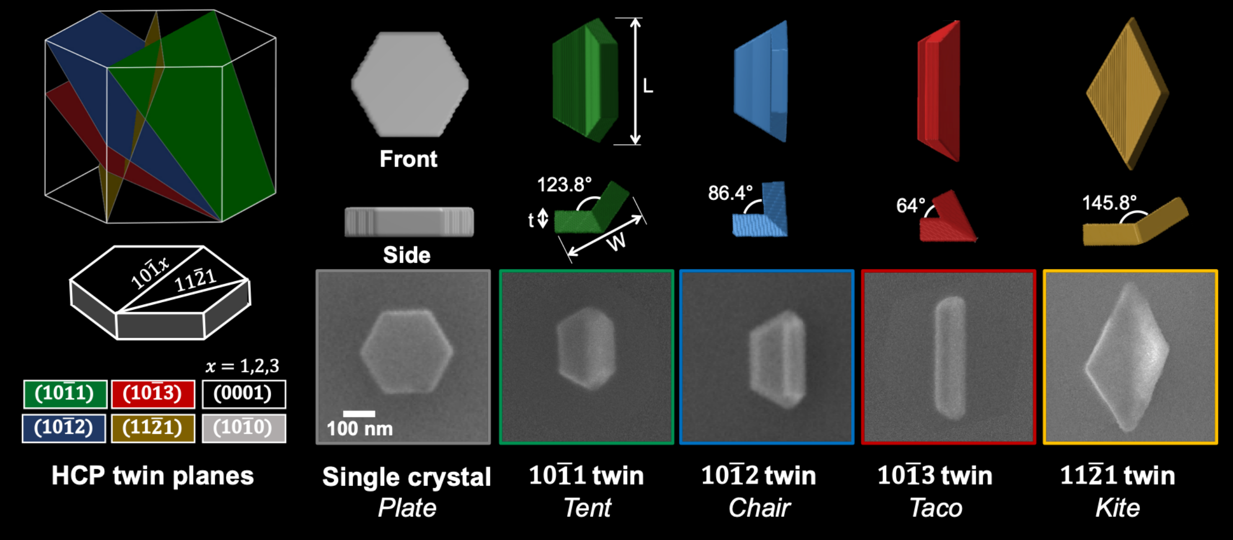
- Plasmon resonances spanning the UV-Vis-NIR range(2);
- Lower ϵ_i (losses) than Al from 200 to 900 nm(3);
- Lower ϵ_i (losses) than Au and Ag in the UV region(4).

Synthesis of Mg nanoparticles(5,6)





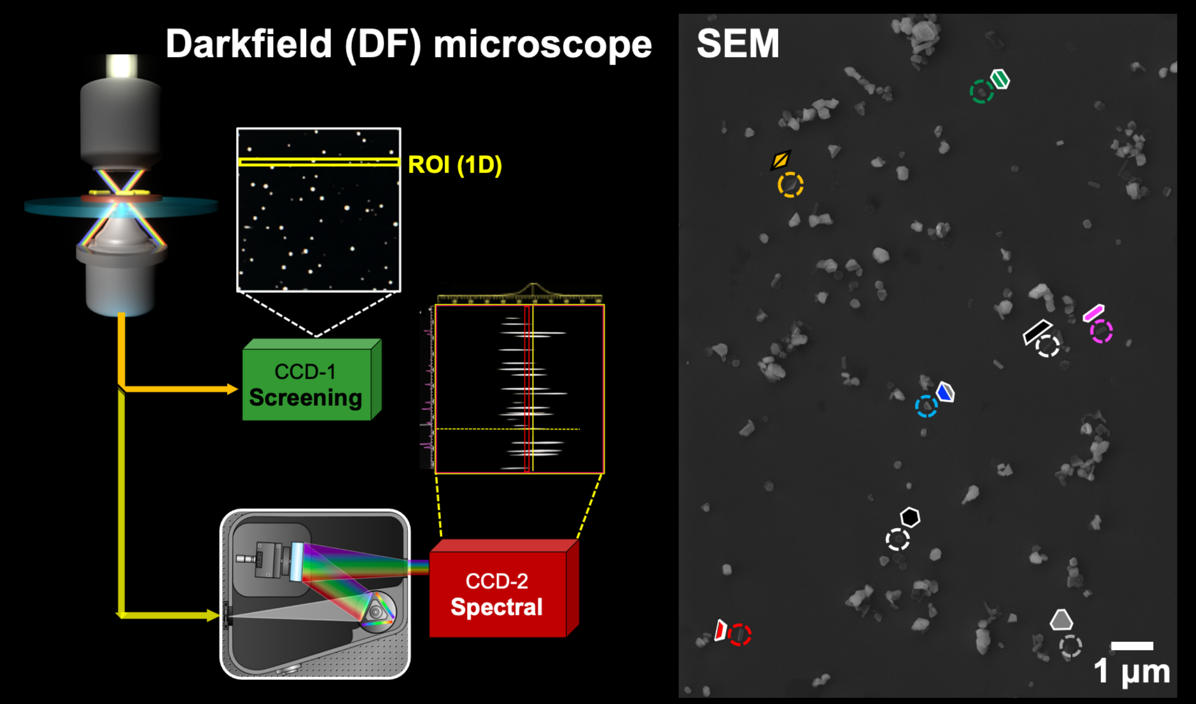


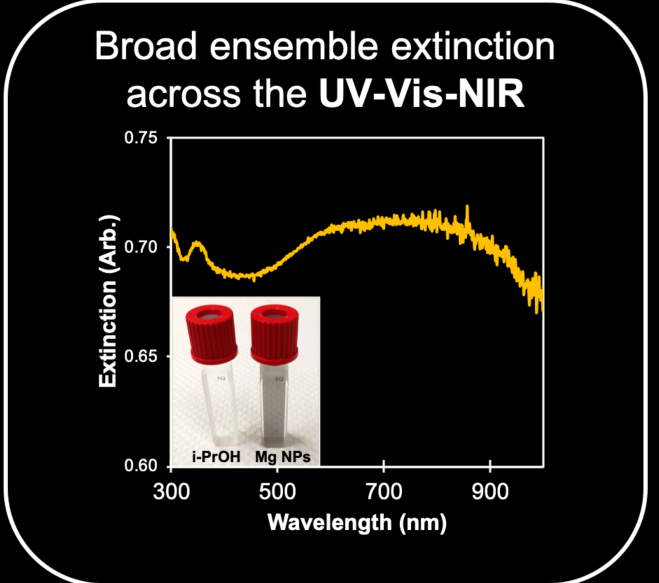


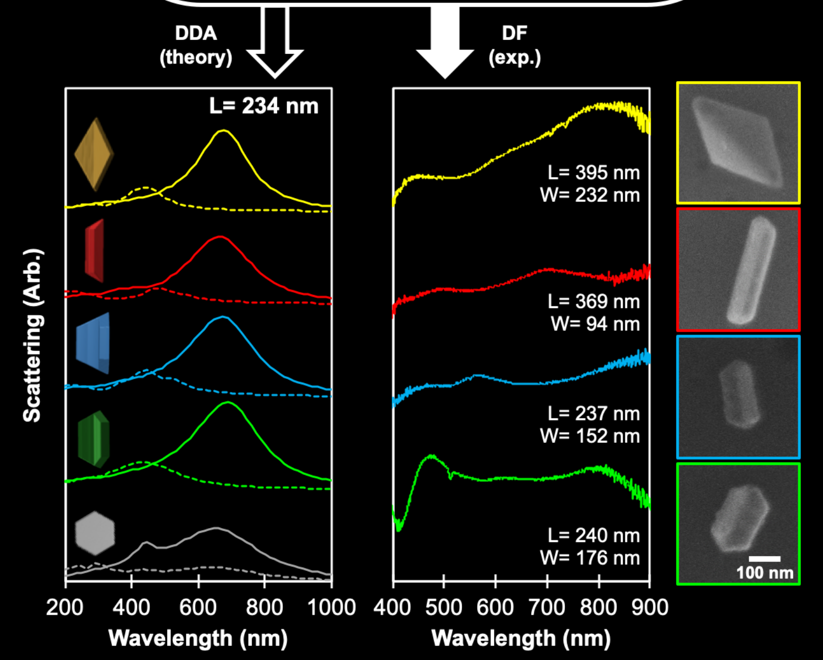
Single-particle characterisation(7)

Optical scattering signatures

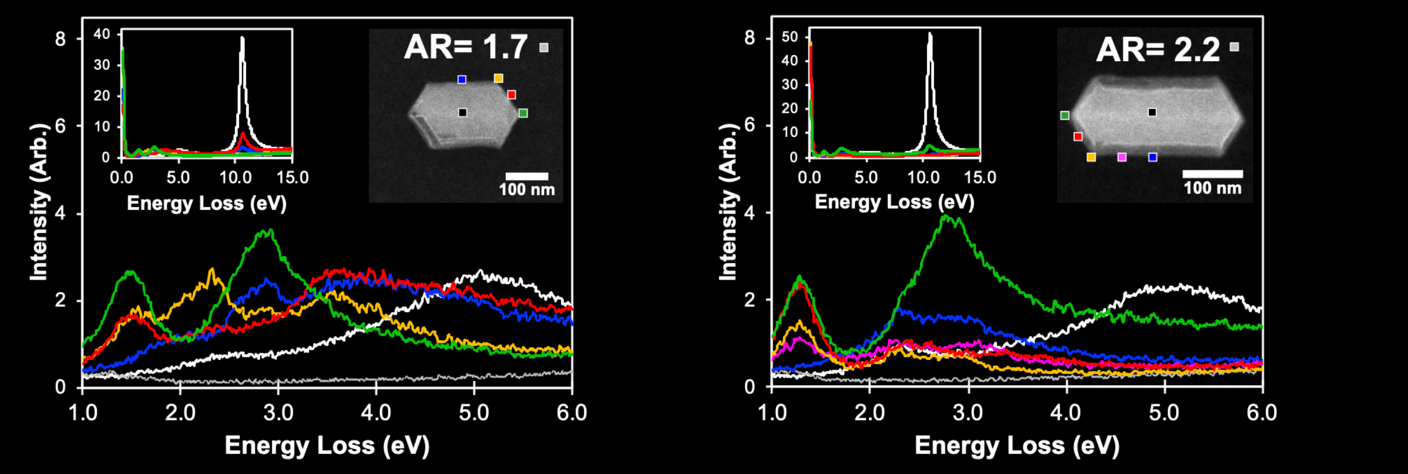
The air-free preparation of Mg NPs produces a certain **polydispersity of sizes and shapes** in suspension. Correlation of optical scattering signatures (hyperspectral data) and scanning electron microscopy data (SEM) provides crucial statistics to help optimize colloidal syntheses. A single synthesis can thus provide statistically relevant trends for different sizes and shapes of NPs.





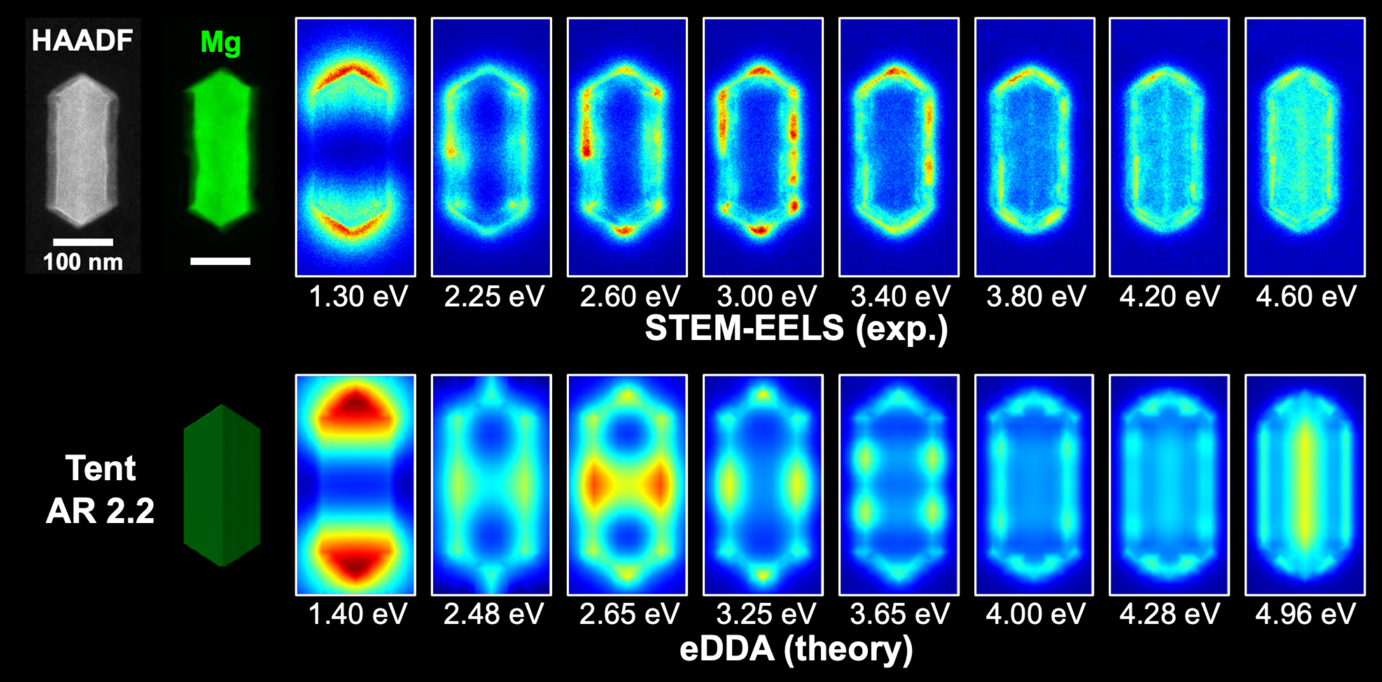


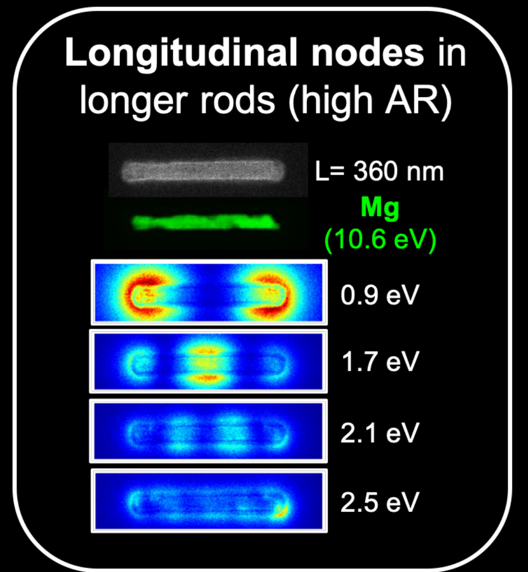
Electron Energy Loss Spectroscopy (EELS)



The Mg metal core has a **bulk plasmon** at 10.6 eV, along with many modes ranging from 1 to 6 eV (1200 to 200 nm, approx.)

Longitudinal and transverse dipoles are observed in elongated NPs at redshifted energies for high aspect ratio (AR) twinned rods.

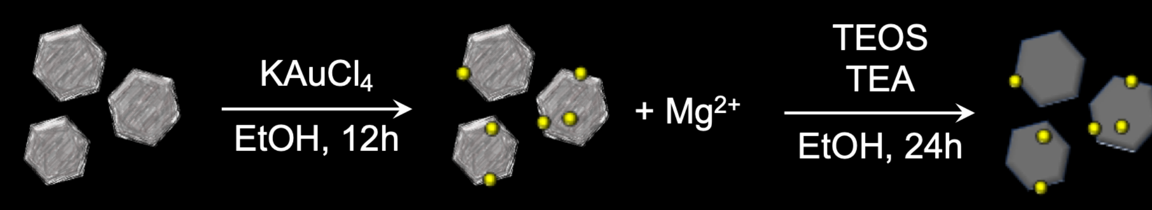


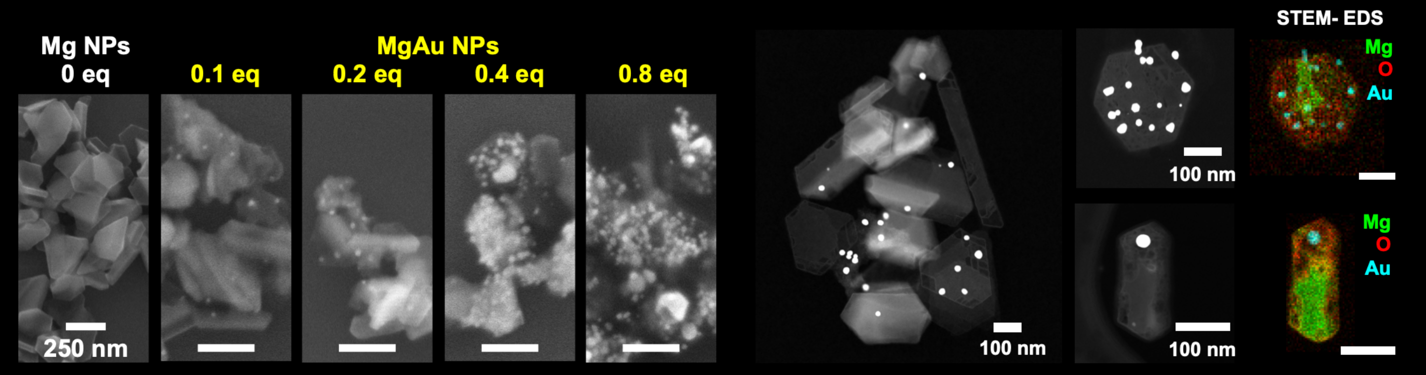


Noble metal decorations on Mg NPs(8)

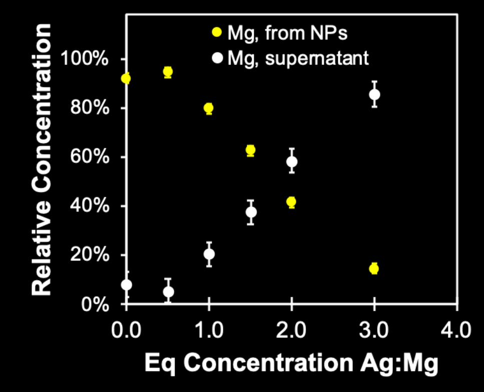
The reducing properties of Mg(0) can be used to produce small noble metal seeds, and thus add novel functionalities in a bimetallic assembly.

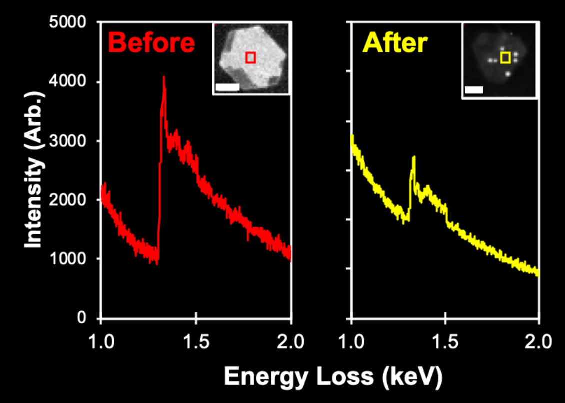
Mg^0	$Mg^{II} + 2e^-$	ΔE_{SH} = **+2.37 V**
$Au^{3+} + 3e^-$	Au^0	ΔE_{SH} = **+1.52 V**
$Ag^+ + 1e^-$	Ag^0	ΔE_{SH} = **+0.80 V**





Galvanic replacement was monitored by Mg dissolution (ICP-MS) after decoration, and oxidation state (EELS) of single NPs.





Conclusions

The addition of **magnesium** in the plasmonic toolbox offers inexpensive and stable NPs as sustainable alternatives to noble metal, while supporting plasmons spanning the entire UV-Vis-NIR spectrum. Mg NPs also present interesting chemical properties for galvanic replacement reactions (with Au, Ag, Pd, Fe).

References & Acknowledgments

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