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# Enhancing Mechanical Properties of PVDF Polymers through Iron Oxide Nanoparticle Reinforcement:

## An Investigation into Materials Behavior

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### 1. Introduction

This research explores nanoparticles' (NPs) potential to enhance polymer matrices' properties, a promising area in materials science. The study focuses on synthesizing iron oxide nanoparticles ( $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>) and their integration into polyvinylidene fluoride (PVDF) matrices. The primary objective is to investigate the relationship between the physical characteristics of nanoparticles, such as size and surface chemistry, and their effect on the mechanical properties of the PVDF matrix.

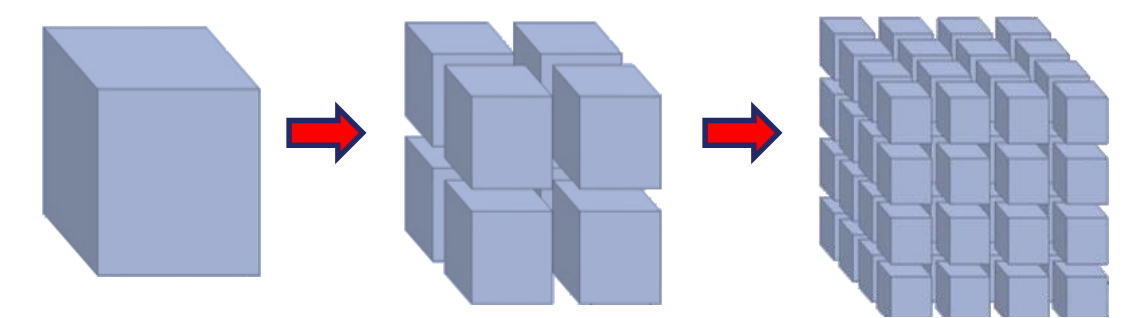
The study uses thermal decomposition to synthesize iron oxide nanoparticles with controlled attributes (Size, surface chemistry, and morphology) and incorporates them into the PVDF matrix through co-axial electrospinning. The resulting nanocomposites are analyzed using advanced characterization techniques to understand how the nanoparticle characteristics influence the performance of polymer matrices (Stiffness and polarization).

### 2. Background

#### Size Effect

Smaller nanoparticles enhance their interaction with the polymer matrix, leading to increased stiffness in the nanocomposite.[1]

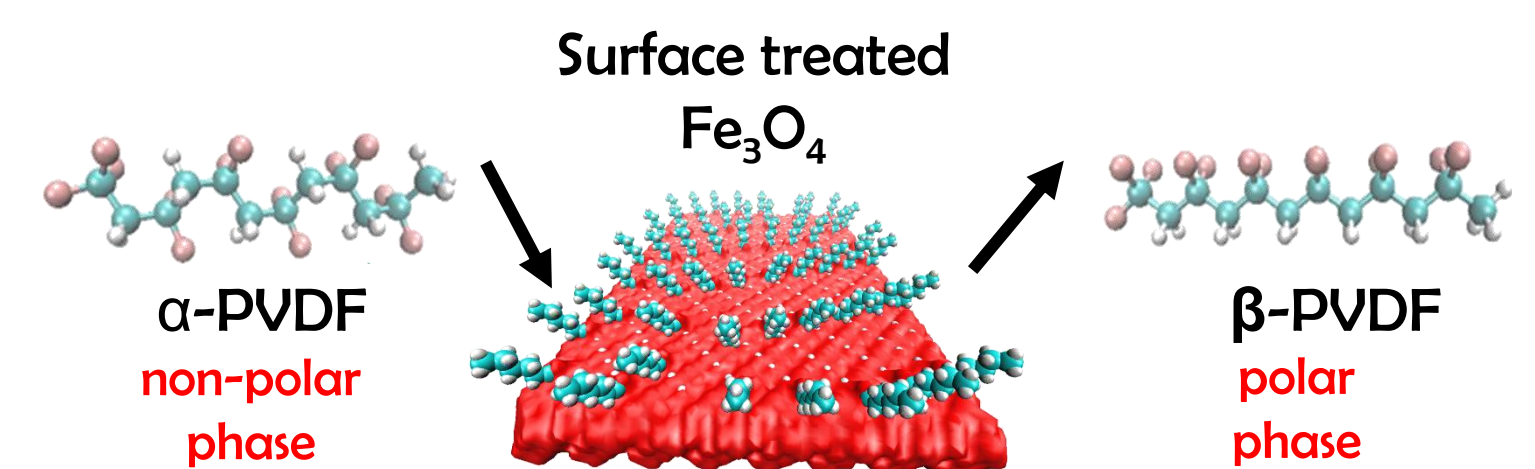
NPs size  $\searrow$   
Ratio surface/ Volume  $\nearrow$



#### Surface Chemistry Effect

Shorter ligands lead to better charge transfer and greater polarization of the polymer. [2]

Ligand chain length  $\searrow$   
PVDF Polarization  $\nearrow$



### 3. Iron oxide nanoparticle synthesis and control

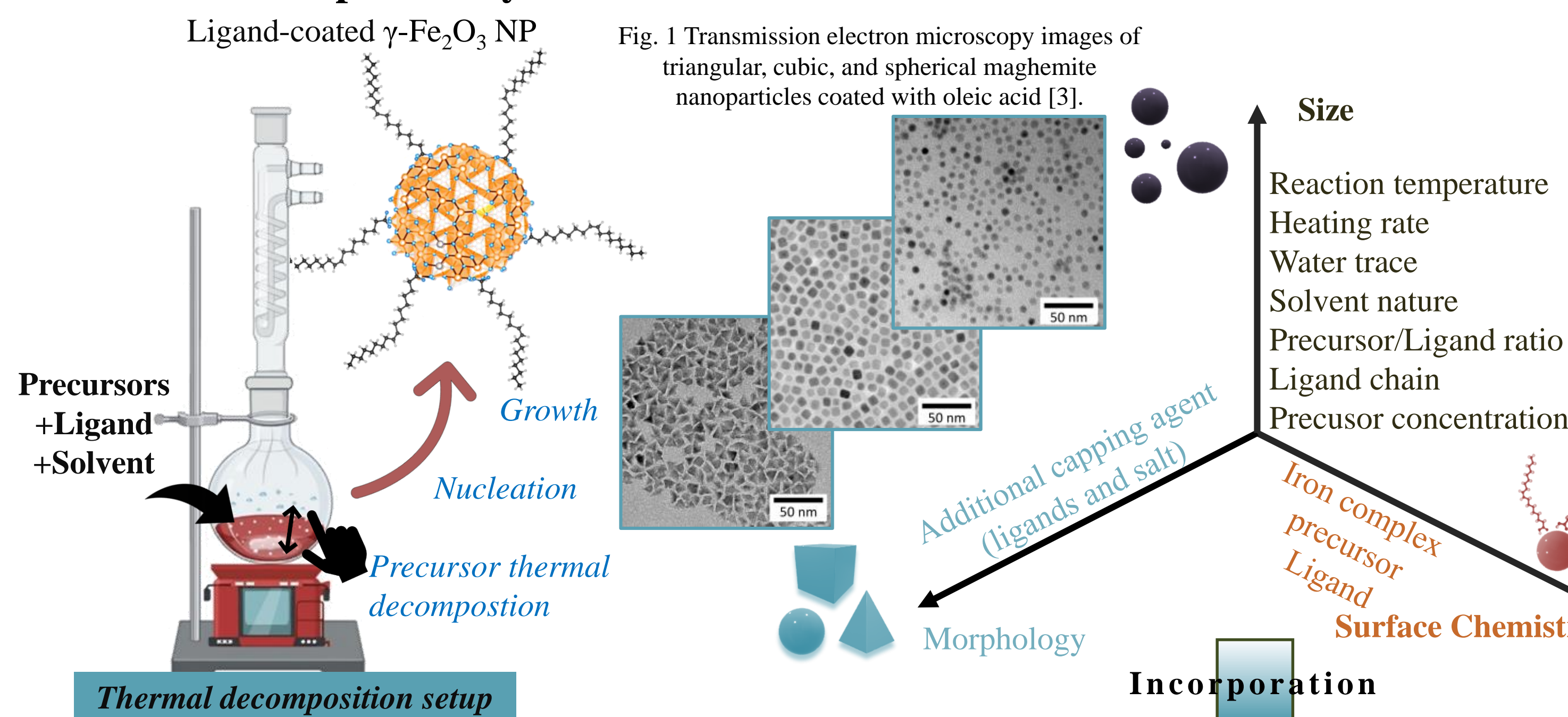


Fig. 1 Transmission electron microscopy images of triangular, cubic, and spherical maghemite nanoparticles coated with oleic acid [3].

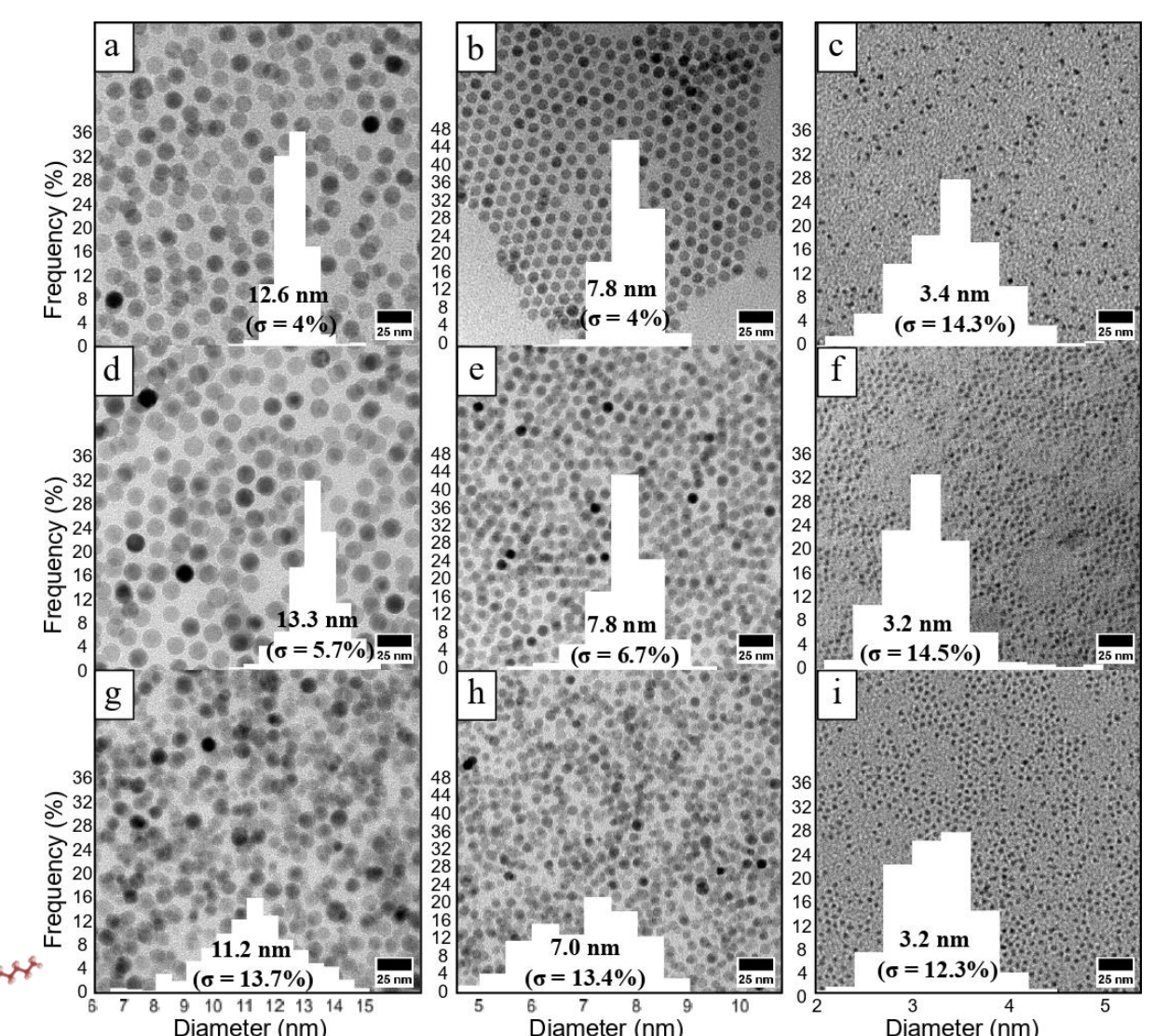
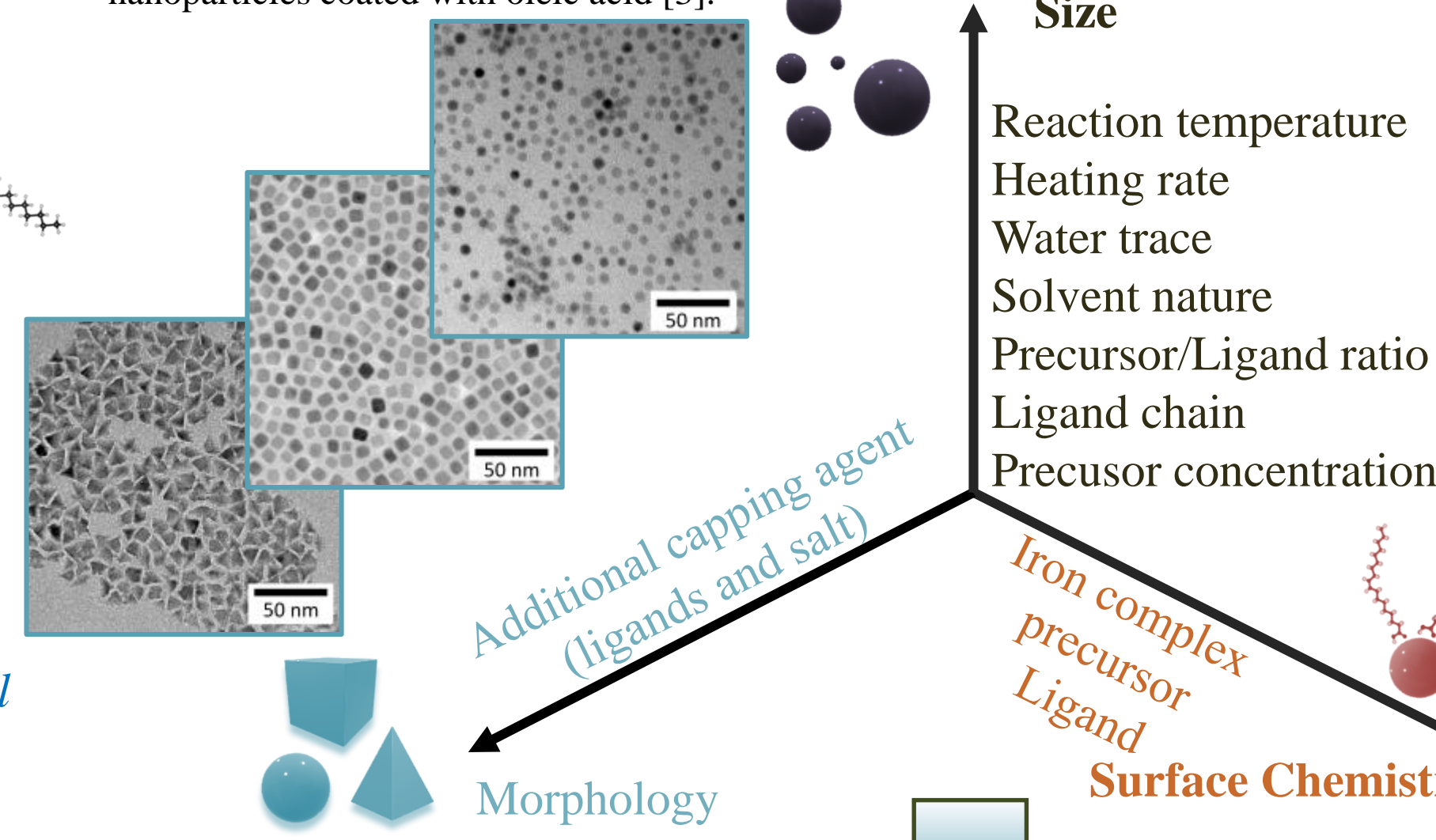


Fig. 2 Transmission electron microscopy images of maghemite nanoparticles coated with (a,b,c) oleic acid, (d,e,f) dodecanoic acid, and (g,h,i) octanoic acid. The mean diameters are centered on (a,d,g) 12 nm, (b,e,g) 7.5 nm and (c,f,i) 3.3 nm [4].

### 4. PVDF nanocomposites synthesis and characterization

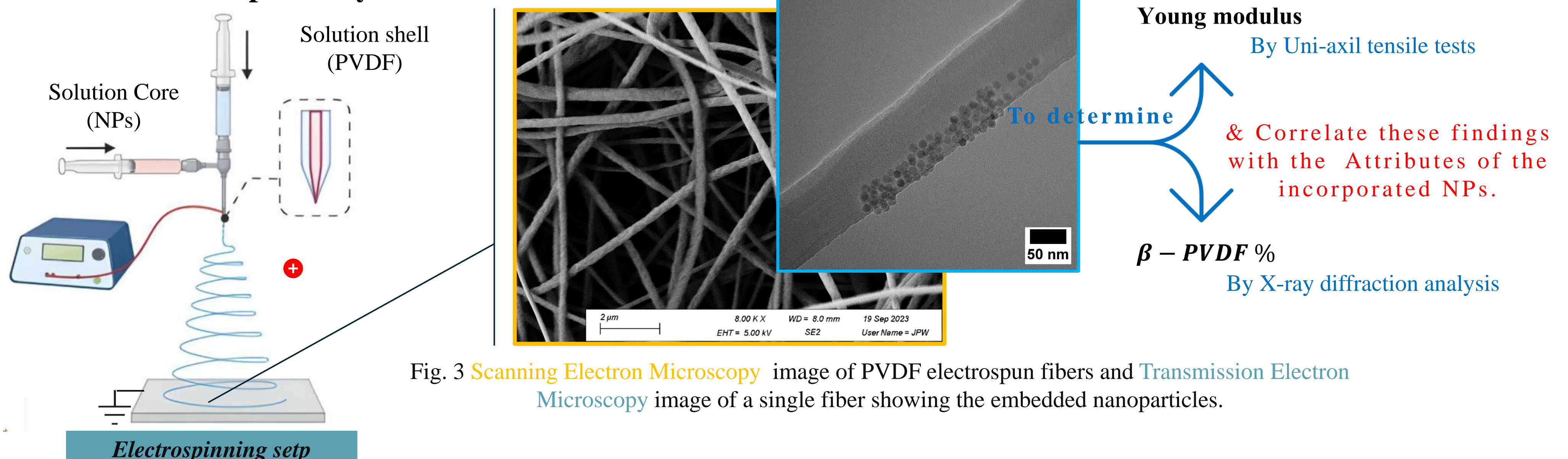


Fig. 3 Scanning Electron Microscopy image of PVDF electrospun fibers and Transmission Electron Microscopy image of a single fiber showing the embedded nanoparticles.

### 5. References

[1] Navarro Oliva, F.S. et al. (2023). Polymer Testing, 117, 107851. [2] Sahihi, M. et al. (2021). J. Phys. Chem. C, 125(39), 21635-21644. [3] Meftah, S. et al. (2024). Colloids and Surfaces A 680, 132689. [4] Meftah, S. et al. (Submitted).