



HAL
open science

Precise Control of Maghemite Nanoparticles Morphology, Size, and Surface Chemistry

Sakina Meftah, Djimédo Kondo, Anh-Tu Ngo, Isabelle Lisiecki, Fahmi Bedoui

► **To cite this version:**

Sakina Meftah, Djimédo Kondo, Anh-Tu Ngo, Isabelle Lisiecki, Fahmi Bedoui. Precise Control of Maghemite Nanoparticles Morphology, Size, and Surface Chemistry. 1ères journées du GDR Multi-PODE “Multifunctional nanostructured POLYmer systems by DEsign”, Sep 2024, Sophia Antipolis, France. hal-04733434

HAL Id: hal-04733434

<https://hal.science/hal-04733434v1>

Submitted on 12 Oct 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Precise Control of Maghemite Nanoparticle Morphology, Size, and Surface Chemistry

Insights from Precursor Selection and Synthesis Parameters

Sakina MEFTAH^{1,2}, Anh-tu NGO², Djimedo KONDO³, Isabelle LISICKI², Fahmi BEDOUI^{1,4}

¹Université de technologie de Compiègne, Roberval (Mechanics, energy and electricity), Centre de recherche Royallieu - 60200 Compiègne, France

²Sorbonne Université, CNRS, De la Molécule aux Nano-Objets: Réactivité, Interactions Spectroscopies, MONARIS, 75005 Paris, France

³Sorbonne Université, CNRS, Institut Jean Le Rond D'Alembert, 75005 Paris, France

⁴Materials and Process Simulation Center, California Institute of Technology, Pasadena, California 91106, USA

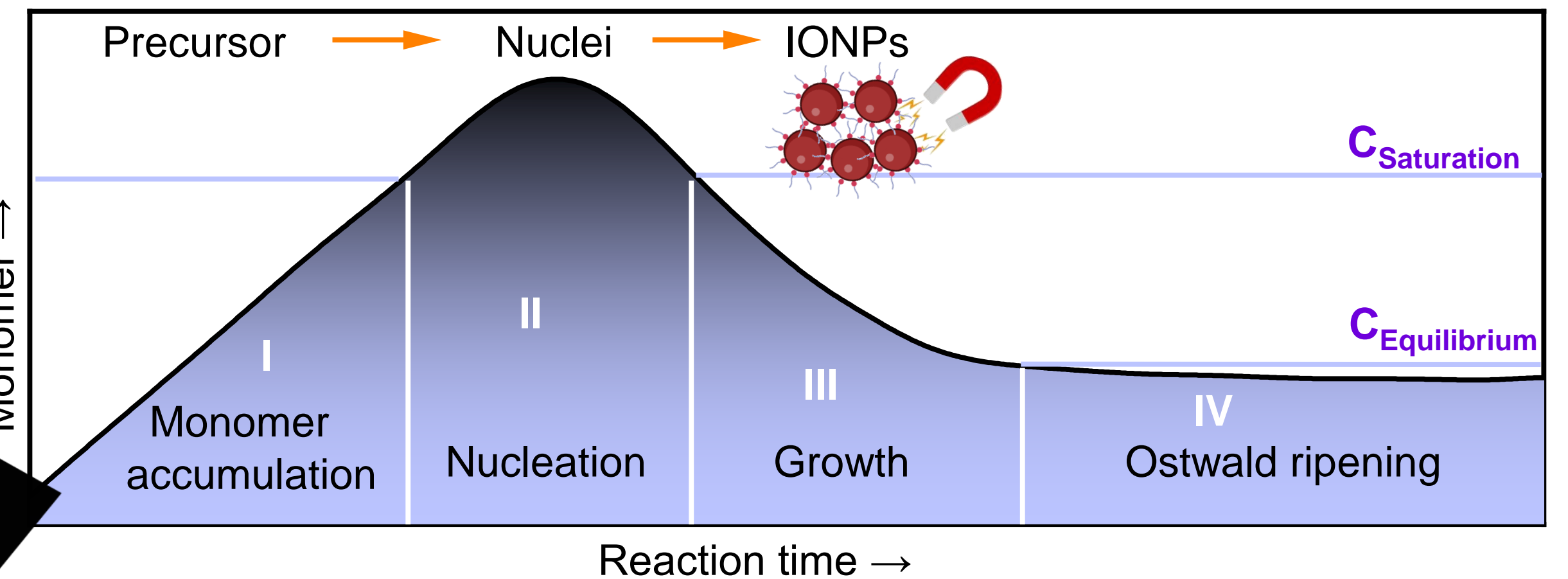
Context

Iron oxide nanoparticles (IONPs) possess unique magnetic properties that make them valuable in biomedical imaging, drug delivery, and catalysis. Controlling their **size**, **surface chemistry**, and **morphology** is crucial for optimizing performance in these applications. Thermal decomposition is an effective method for synthesizing IONPs with precise control over these parameters. This study explores how varying synthesis conditions can tailor IONP properties for enhanced functionality in practical applications.

Set Up



Process



Results

MORPHOLOGY CONTROL

Purity of Iron(Stearate)₃ precursors

Poisoning the surface with different agents varies the growth rates on low index planes such as {111}, {110} and {100}.

*SODIUM STEARATE

6x(100)

6x(100), 8x(111)

*SODIUM STEARATE
*SODIUM CHLORIDE

8x(111)

%Fe	25
%Na	48
%Cl	27

%Fe	100
%Na	0
%Cl	0

%Fe	43
%Na	44
%Cl	3

SURFACE CHEMISTRY CONTROL

Length of Iron(carboxylate)₃ precursors

Thermal decomposition
Oleic acid-coated IONPs
Dodecanoic acid-coated IONPs
Octanoic acid-coated IONPs

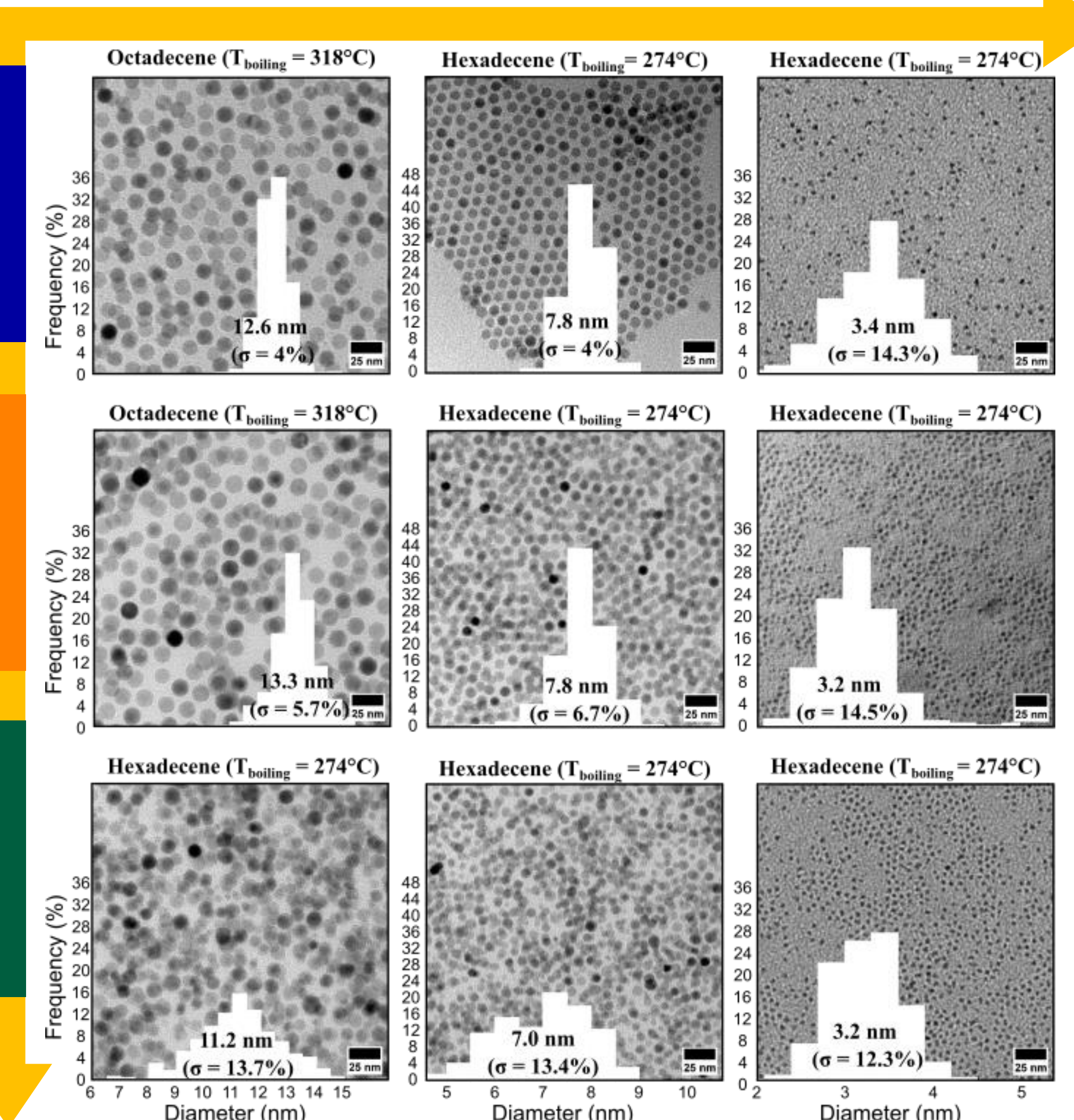
Each precursor has a different decomposition mechanism, so various growth mechanisms need to be investigated for size control.

Results

SIZE CONTROL

Reaction temperature | Precursor to Ligand ratio | Ligand chain | Precursor concentration

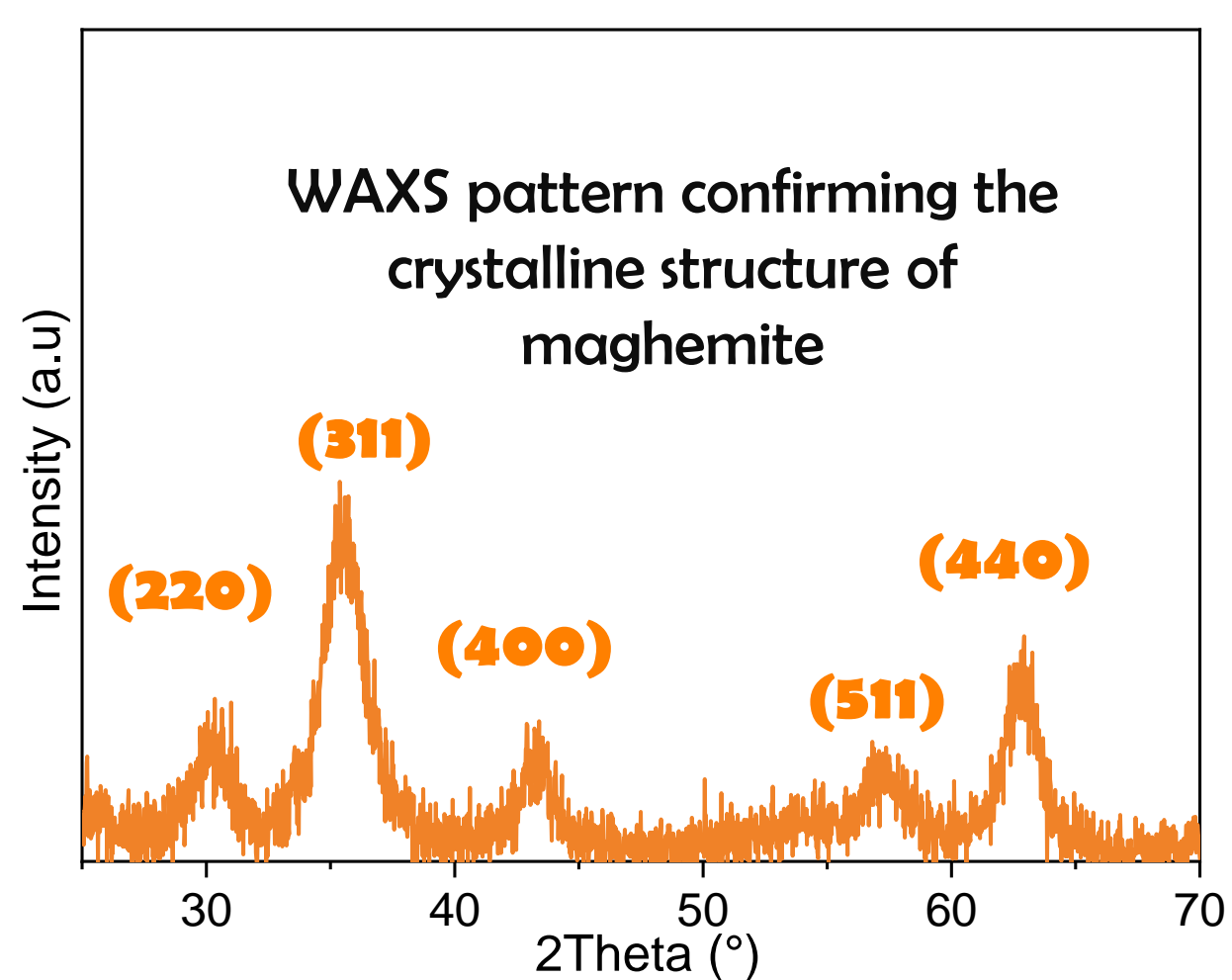
12 nm 7 nm 3.5 nm



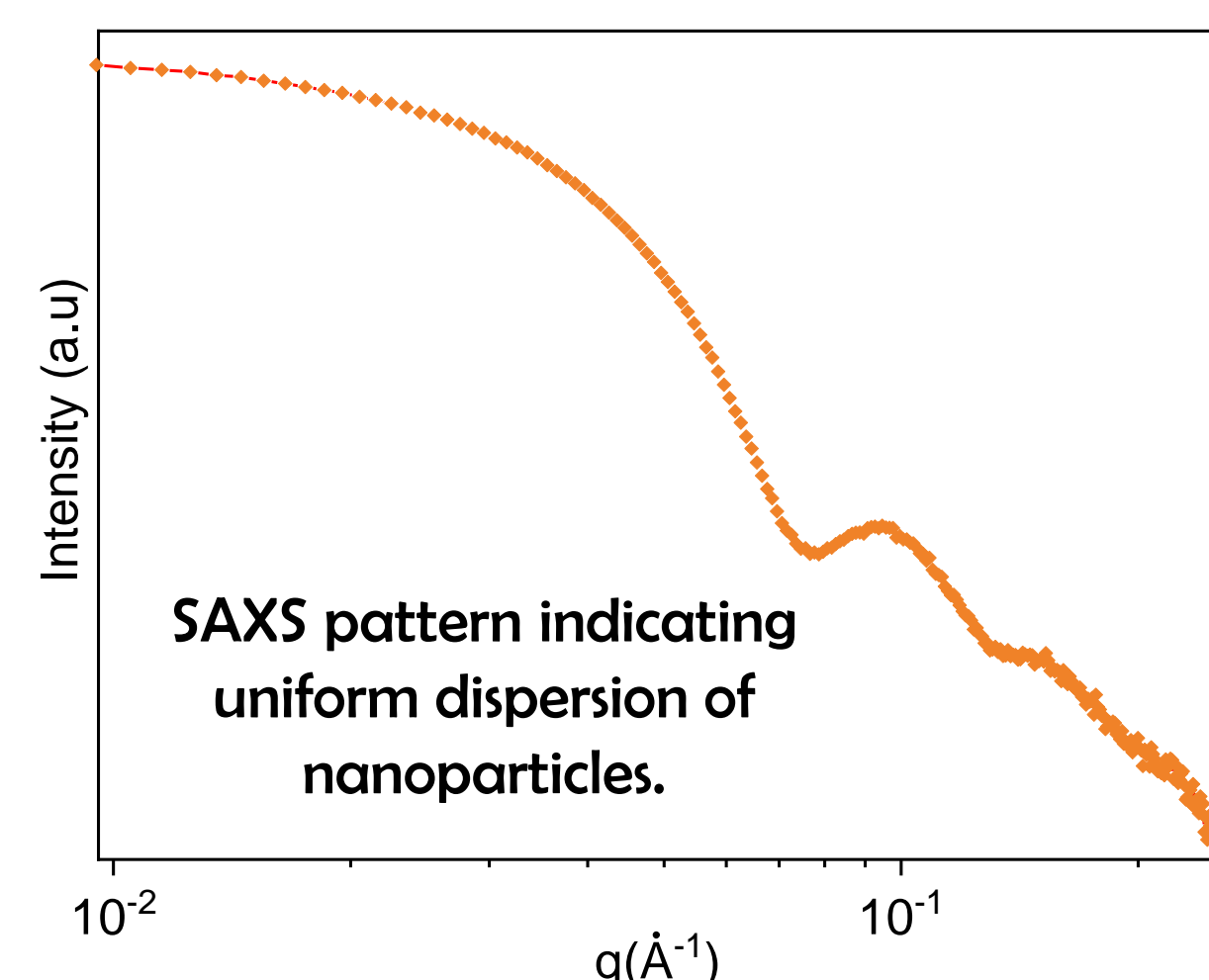
Meftah, S., et al. "Effect of iron stearate purity on maghemite nanoparticle shape and size." *Colloids Surf. A* 680 (2024): 132689.

Meftah, S., et al. "Synthesis and magnetic properties of spherical maghemite nanoparticles with tunable size and surface chemistry" under review.

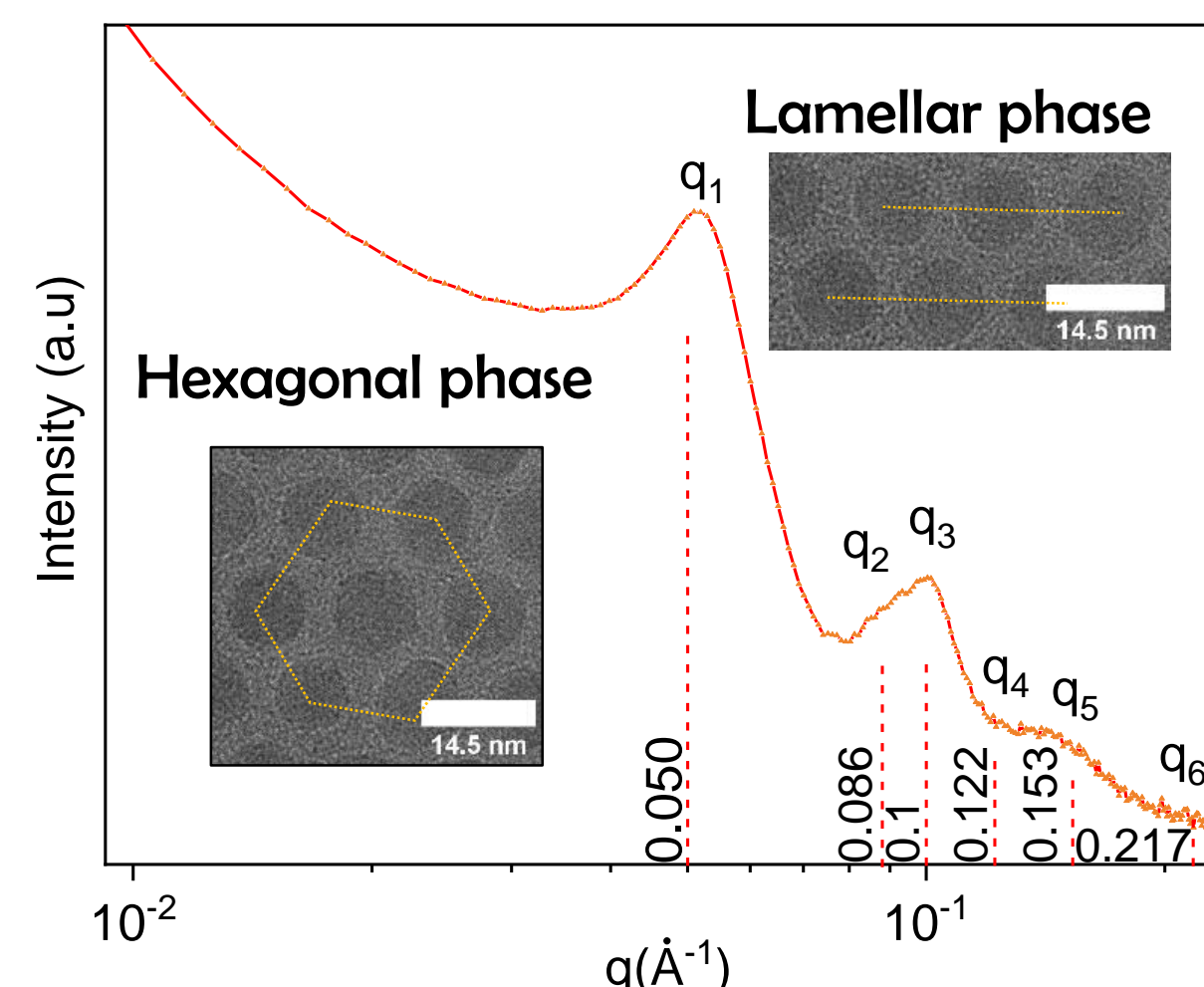
Composition



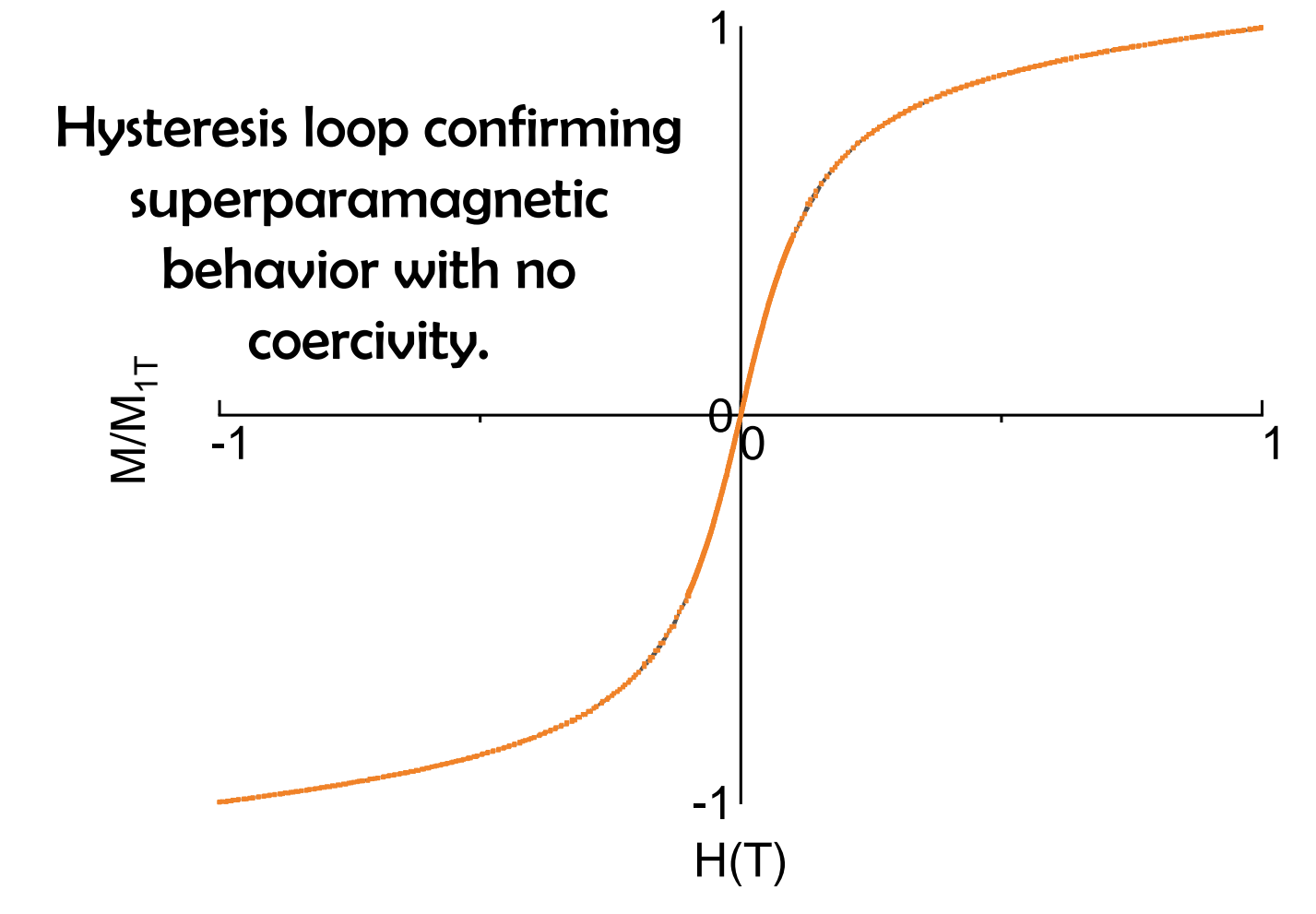
Dispersion in a solution



Dispersion in a solid



Superparamagnetism



Conclusions

Our study revealed critical insights into iron oxide nanoparticle synthesis:

1. Impurity quantification in iron stearate precursors enabled precise control over nanoparticle morphology, including uniform cubic and triangular shapes.
2. Size control was achieved, producing iron oxide nanoparticles centered at **12 nm, 7 nm, and 3.5 nm**.
3. Surface chemistry tailoring resulted in distinct carbon chain lengths of **8, 12, and 18** for each size.

This unprecedented level of control over morphology, size, and surface chemistry opens new avenues for optimizing iron oxide nanoparticles for diverse applications in fields such as biomedicine, catalysis, and environmental remediation.

Perspectives

The findings open exciting avenues for research into how nanoparticle size (**12 nm, 7 nm, 3.5 nm**) influences the **mechanical** and **thermal properties** of polymer nanocomposites. Additionally, the impact of surface chemistry, particularly the effects of different carbon chain lengths (**8, 12, 18**) on polymer-nanoparticle interactions and overall composite performance, warrants exploration. The influence of nanoparticle morphology (**cubic** and **triangular**) on anisotropic behaviors and processing-structure relationships also presents significant opportunities. These studies will enhance the understanding of iron oxide nanoparticle-polymer systems, enabling the design of advanced nanocomposites for diverse applications.

