Building thick spinel iron oxide layer onto the hexaferrite core nanoparticles using multiple co-precipitation of iron ions

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Introduction

- Composite nanoparticles: different functional materials combined in the single nanoparticle.
- Coupling between the different materials → new chemical and physical properties.
- **Bi-magnetic** materials consist of two different magnetic materials.
- Majority of bi-magnetic nanoparticles posses core/shell structure → strong coupling effect due to large contact area between the materials
- Thickness of the shell can influence on the magnetic properties of the composite nanoparticles

SYNTHESIS OF THE CORE/SHELL NANOPARTICLES

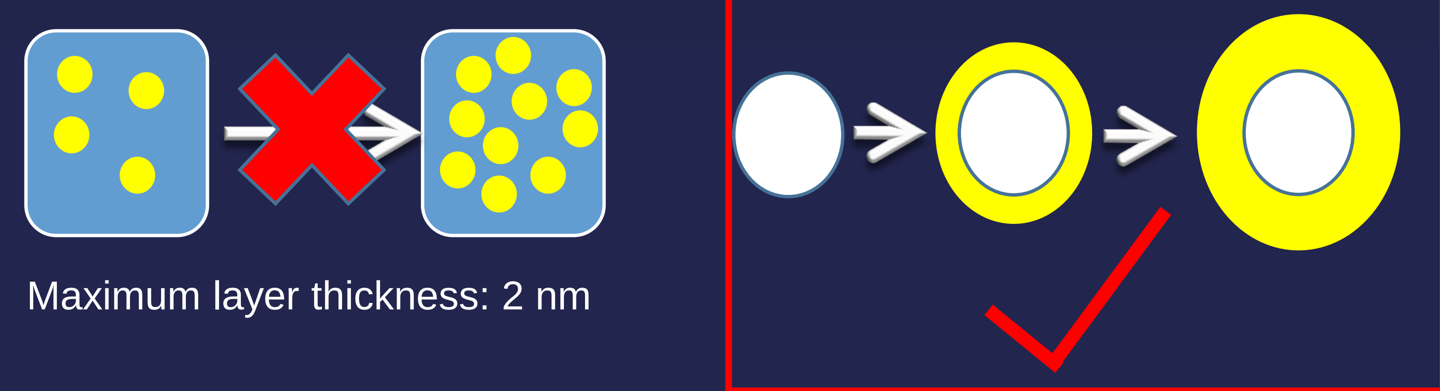
- high temperatures (> 200 °C).
- toxic and expensive reactants.

ALTERNATIVE

- Low temperature synthesis of the magnetic spinel iron oxide (maghemite γ-Fe_2O_3) shell/layer deposited onto the hexaferrite core nanoparticles.
- Method based on the co-precipitation of Fe^{3+}/Fe^{2+} ions and heterogeneous nucleation of the product onto the core nanoparticles [1,2].

Our work

Increasing the layer thicknes



- Investigation of the synthesis procedure aiming to increase the maghemite layer coated onto the hexaferrite core nanoparticles.
- **METHOD:** two-step co-precipitation process of the Fe^{3+}/Fe^{2+} ions in colloidal suspension of the core nanoparticles [2].

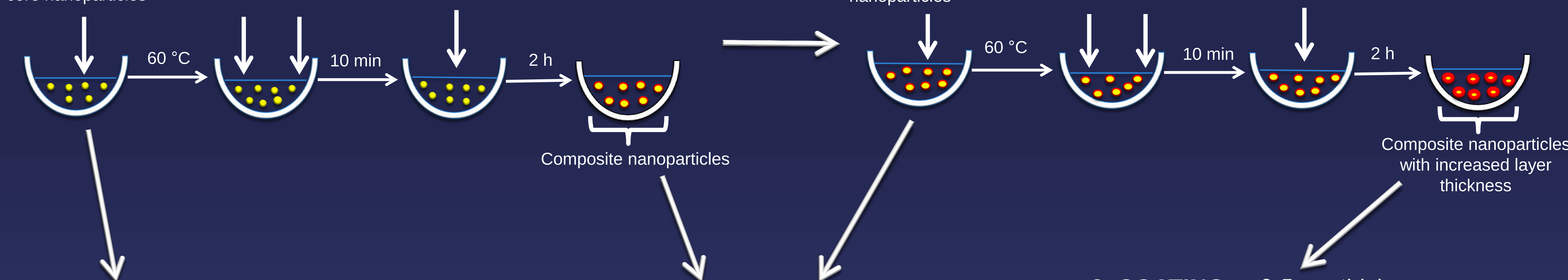
PROBLEMS

Agglomeration of the composite nanoparticles in the second step.

↓

Decreasing of the surfce area available for the growth of the maghemite layer
Agglomeration could promote formation of the homogeneously-nucleated maghemite nanoparticles.

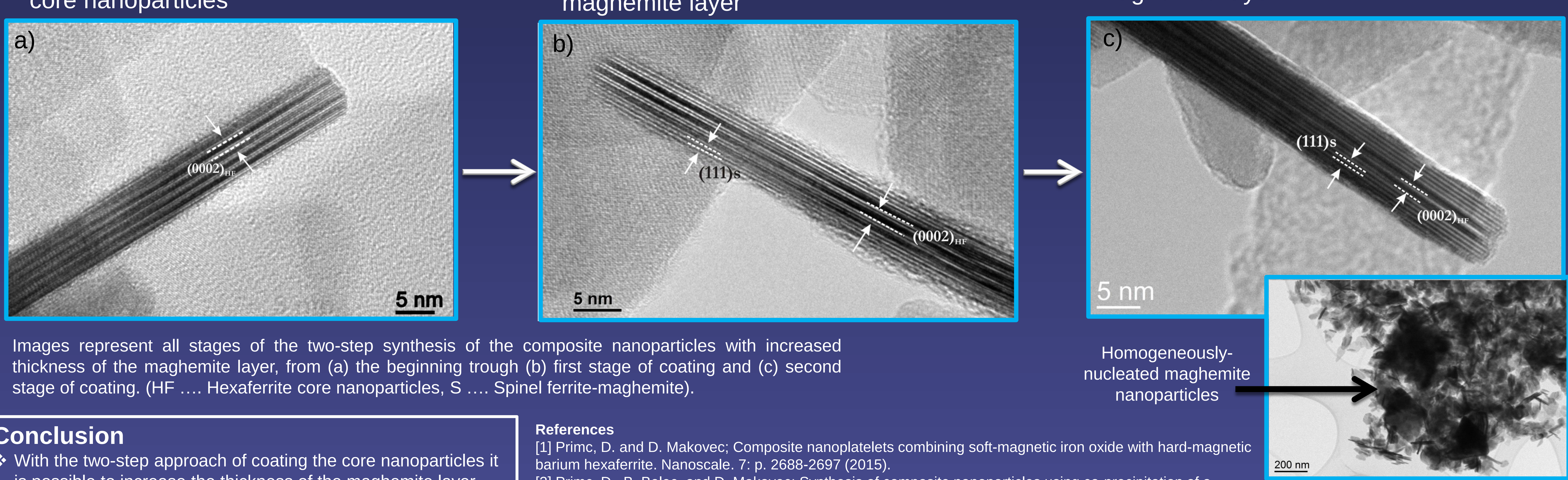
Synthesis



Hexaferrite core nanoparticles

1. COATING: max. 2 nm thick maghemite layer

2. COATING: ≈ 3.5 nm thick maghemite layer



Homogeneously-nucleated maghemite nanoparticles

Images represent all stages of the two-step synthesis of the composite nanoparticles with increased thickness of the maghemite layer, from (a) the beginning trough (b) first stage of coating and (c) second stage of coating. (HF …. Hexaferrite core nanoparticles, S …. Spinel ferrite-maghemite).

Conclusion

- With the two-step approach of coating the core nanoparticles it is possible to increase the thickness of the maghemite layer.
- Further optimization of the synthesis in needed to obtain the homogeneous product, containing only the composite nanoparticles

References

[1] Primc, D. and D. Makovec; Composite nanoplatelets combining soft-magnetic iron oxide with hard-magnetic barium hexaferrite. Nanoscale. 7: p. 2688-2697 (2015).
[2] Primc, D., B. Belec, and D. Makovec; Synthesis of composite nanoparticles using co-precipitation of a magnetic iron-oxide shell onto core nanoparticles. J. Nanopart. Res. (18:64): p. 1-13 (2016).

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