Characterization of various plasma reactors dedicated to nanoparticle functionalization

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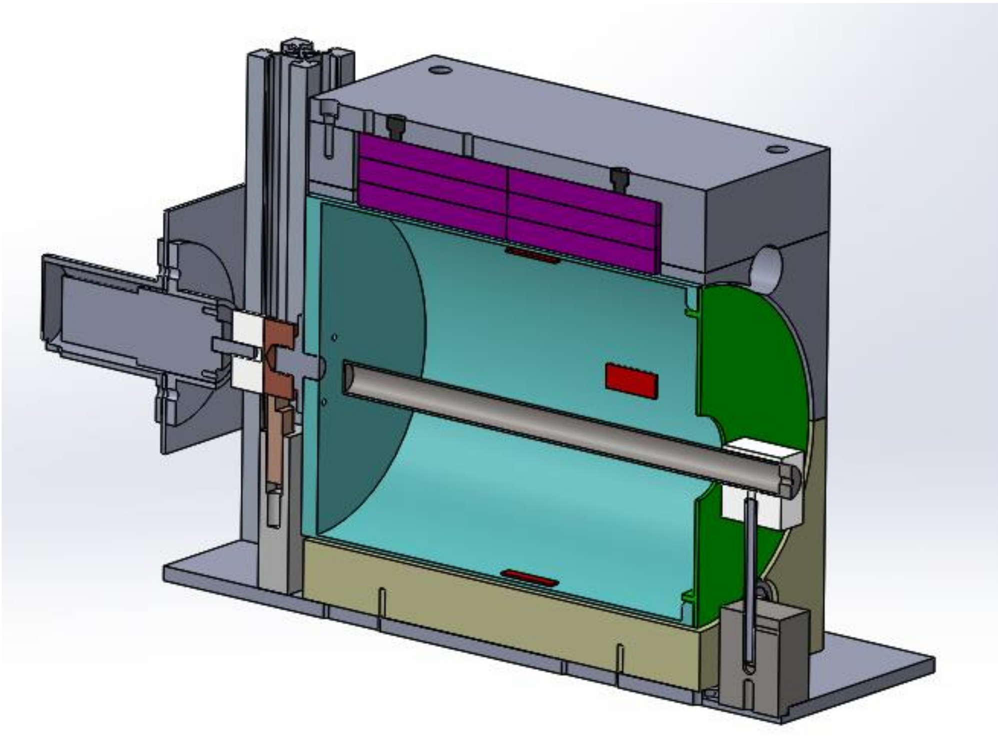
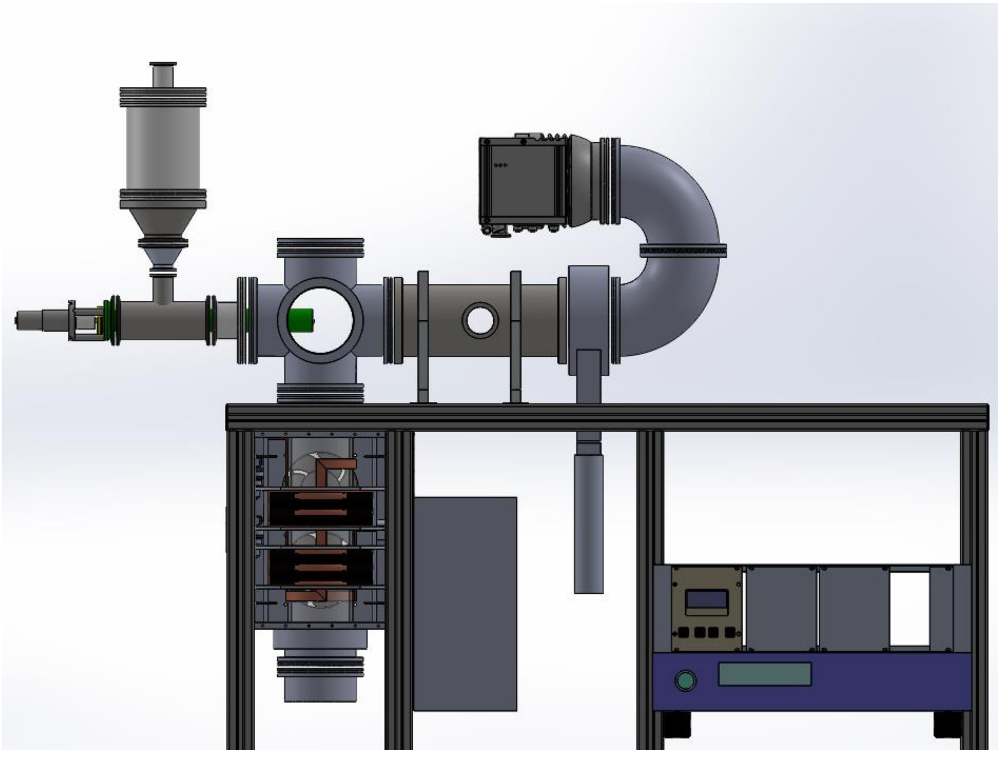
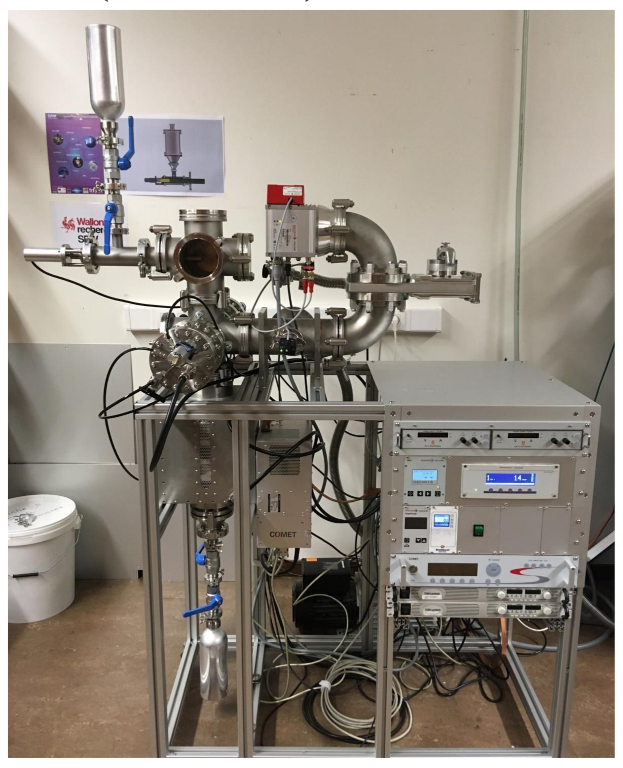
Introduction

The surface treatment of nanoparticles is an essential step in the synthesis of high added value polymer nanocomposite, to avoid nanoparticles agglomeration and create a strong bonding interface with the host matrix. Among existing methods, the deposition of plasma polymers has numerous advantages such as high versatility regarding the incorporation of a chemical functionality, little use of chemicals, simple apparatus, short process time and easy scale-up to mass production. Nevertheless, the plasma treatment of nanomaterials is a challenging task because an effective way to mix the powders during the treatment has to be found in order to obtain a homogeneous coating around isolated nanoparticles. In this purpose, we compare in this work the efficiency of two different types of homemade low-pressure plasma reactors.

Magnetron Rotating Drum Reactor (MRDR) VS RF Gravitational Reactor (RFGR)







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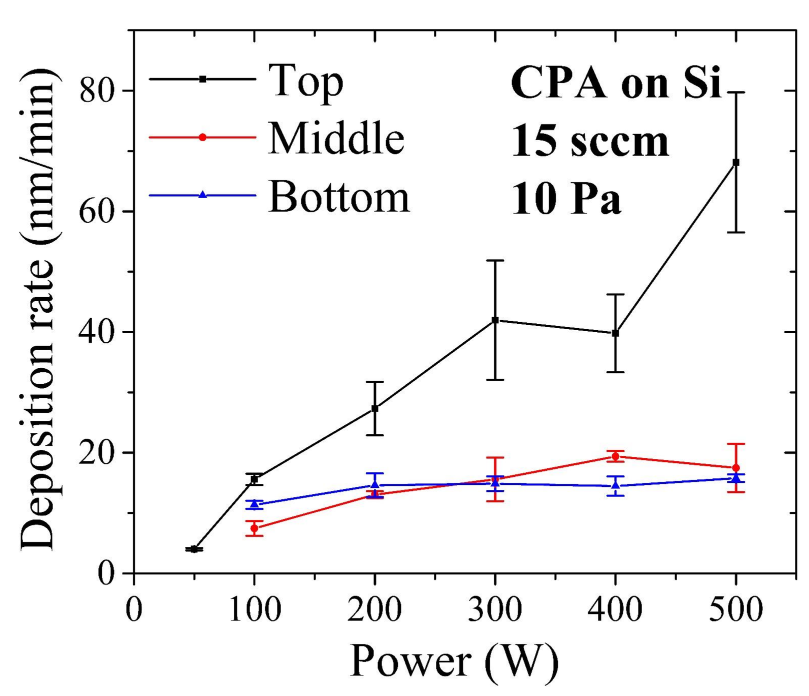
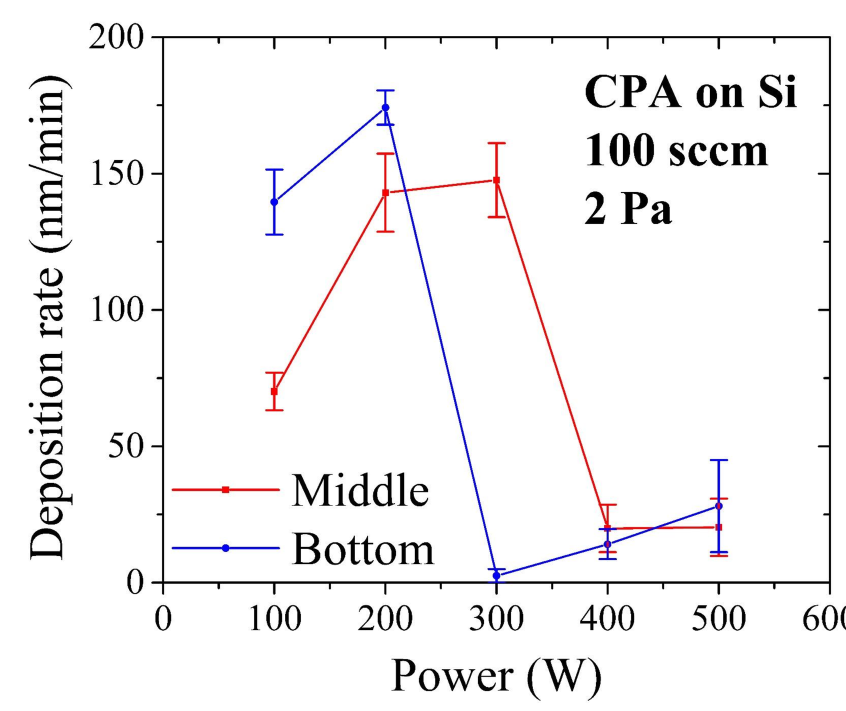
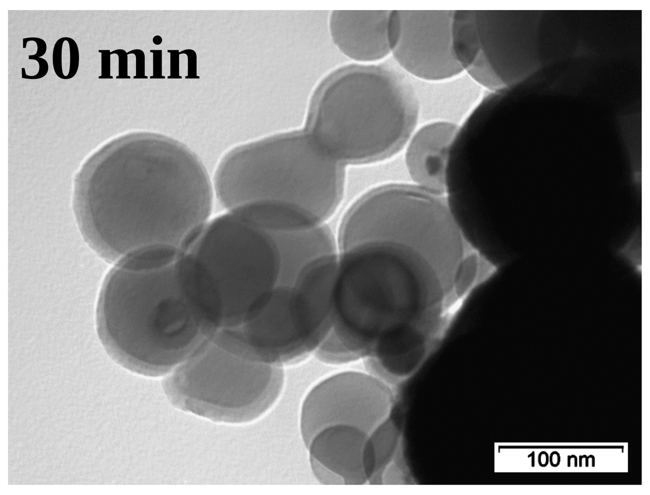
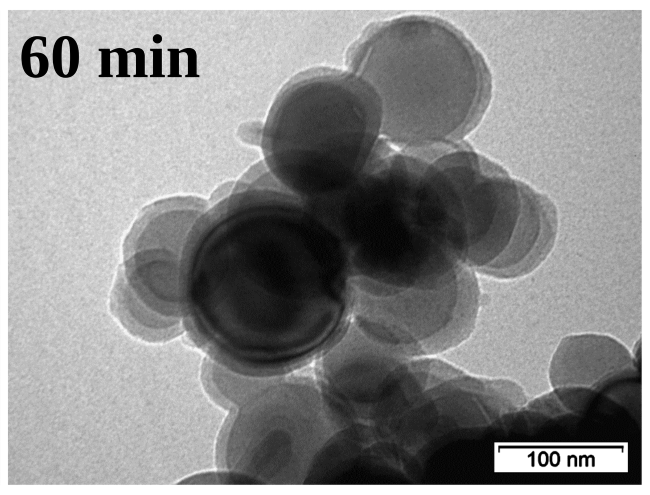


MRDR		RFGR
2.5 → 20 Pa	Pressure range	0.5 → 5 Pa
No restriction	Residence time in the plasma	~ 1 s / run
30 → 160 g/h	Maximal Production rate* (NPs density)	For 10 runs: 10 → 80 g/h
5 → 20 % / batch	Material loss* (Nature of NPs)	~ 3 % / run

* *The values given shall be regarded merely as indicative.* *(Depends on)*

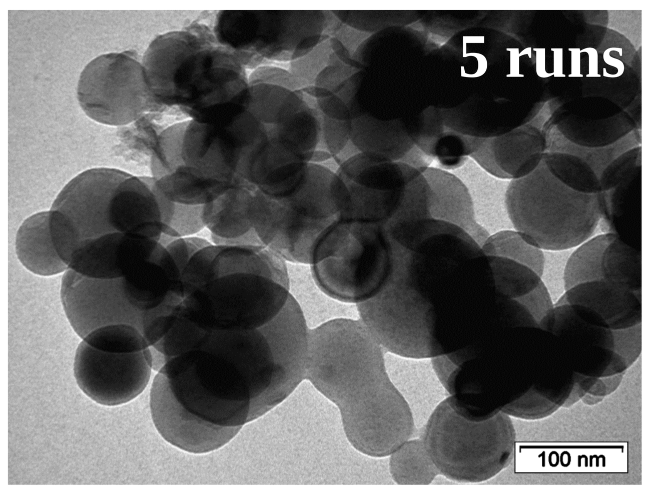


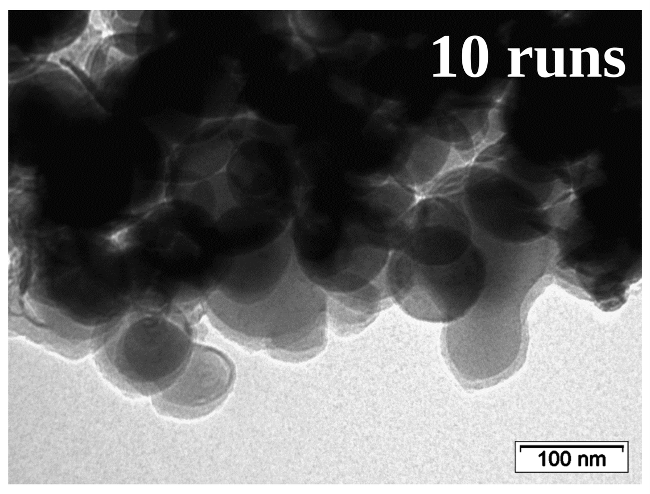




→ Increasing the treatment time leads to thicker coatings.

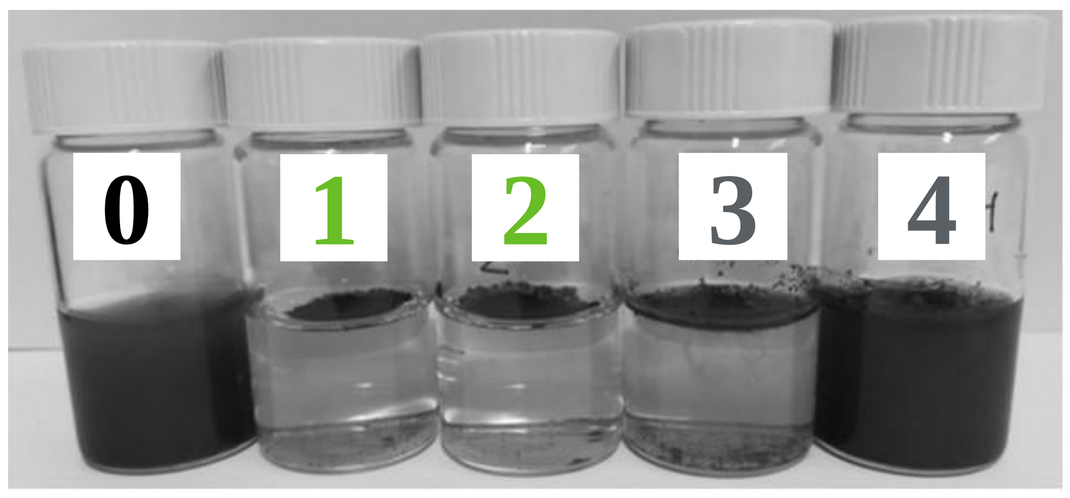
C_2H_2 on Al powders		Atomic concentrations (at. %) Al 2p	C 1s	O 1s
Raw NPs		29.7	25.0	45.3
MRDR	30 min	13.0	63.7	23.3
	60 min	5.5	78.4	16.1
RFGR	5 runs	25.4	35.9	38.7
	10 runs	25.3	35.8	38.9

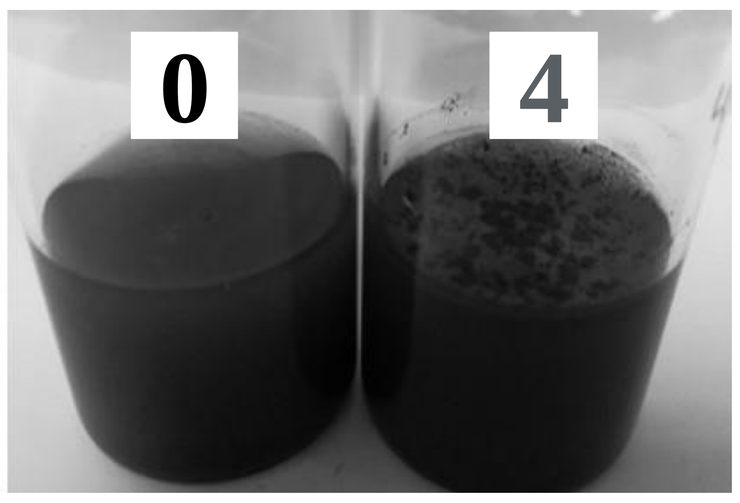




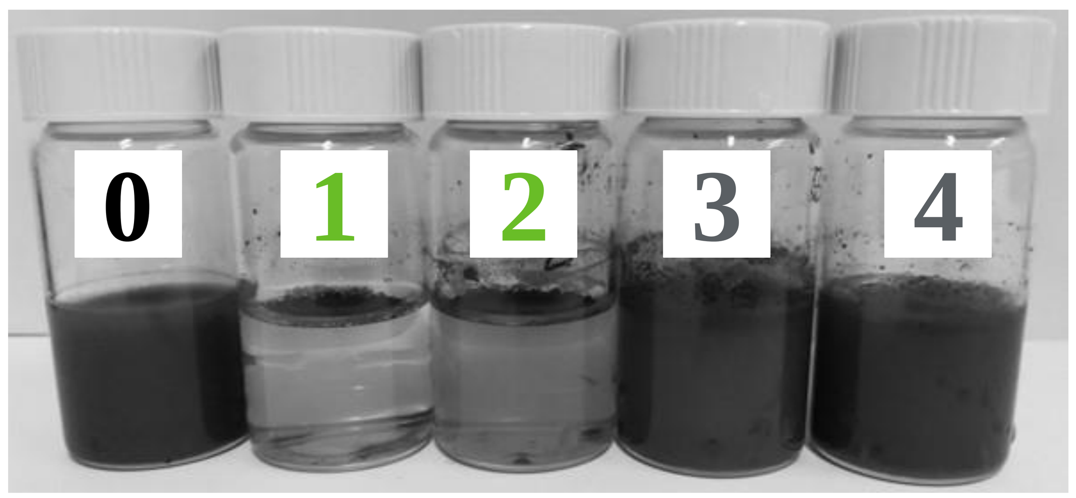
→ Increasing the number of runs enhances the coating uniformity.

MRDR vs RFGR (after H_2O addition)





MRDR vs RFGR (after 10 minutes of sonication)



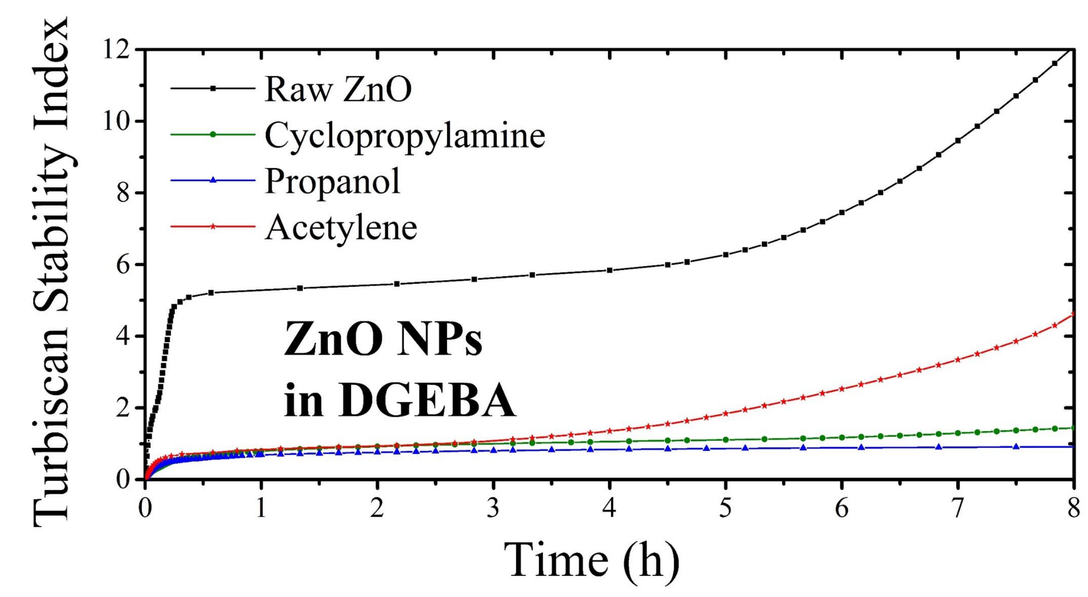
0 – Pristine Al
1 – MRDR – **30 min**
2 – MRDR – **60 min**
3 – RFGR – **10 runs**
4 – RFGR – **5 runs**

Conclusions

→ Two plasma reactors have been developed for the surface functionalization of NPs.

→ The plasma treatment strongly modifies the properties of NPs (hydrophobicity (left), weight distribution (not shown), stability in liquids (below))

→ Better results are currently obtained with MRDR, but RFGR is far from being exploited at its maximum potential.



Wallonie
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