Adding advanced functional properties to nanoparticles via low-pressure plasma coating

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Introduction

Nanoparticles (NPs) are now the object of intense study due to their perspective properties and numerous industrial applications. Some of these applications are facing with several limitations based on excessive reactivity or conversely low affinity to some matrixes. NPs coating can solve these problems creating a protective layer or changing the chemical composition of the surface, which can improve NPs incorporation and distribution in different matrixes.

Motivation

nanoparticles (NPs)
(metal, metal oxides, carbides, ceramics, polymers ….)

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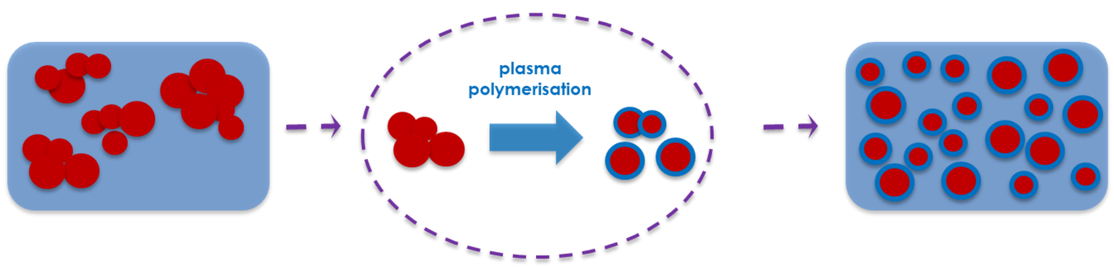
innovative technological applications
(drug delivery systems, sensing devices, energy storage, reinforced composites …)

BUT:
problems of NPs dispersion in matrixes caused by NPs agglomeration

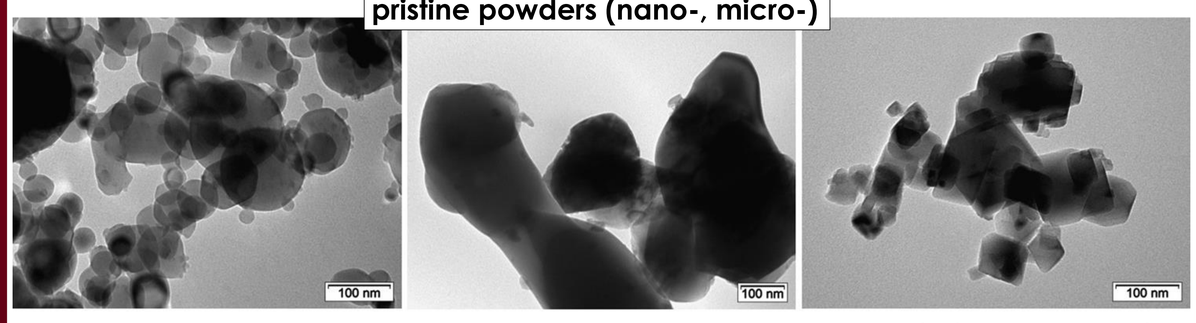
Objective:
to improve the dispersion of inorganic NPs in various matrixes



Solution:
Coating deposition via low pressure plasma discharge
as a **universal method** to ***change surface properties*** of NPs and
to improve their compatibility with the polymer matrix

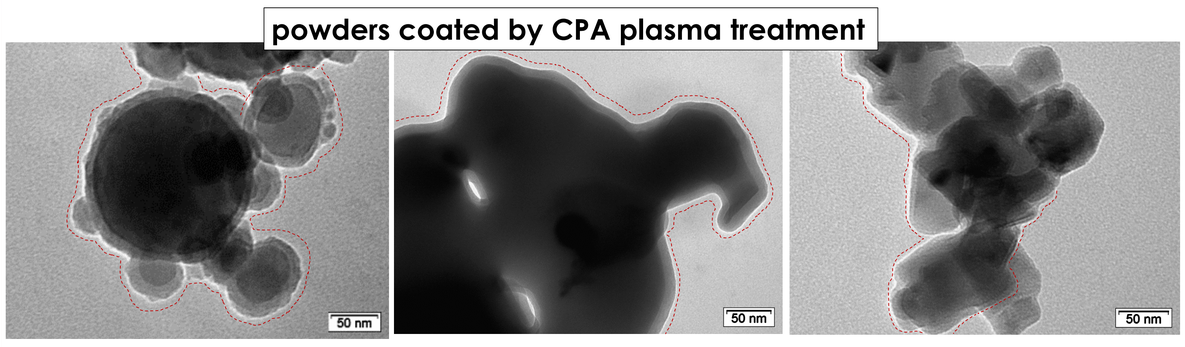
Universal coating for powder materials

pristine powders (nano-, micro-)



Al (spherical, 20-150 nm) Al_2O_3 (irregular, 0.1-5 μm) MgO (cubic, 10-100 nm)

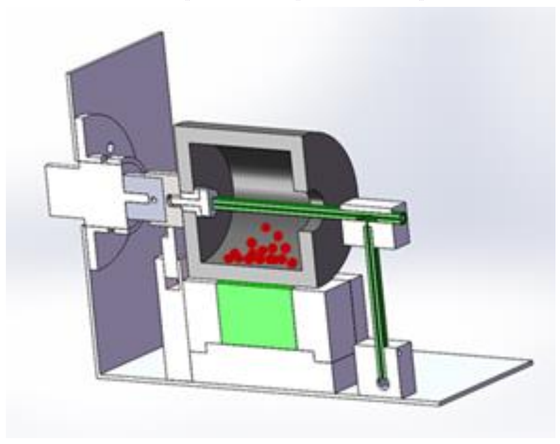
powders coated by CPA plasma treatment



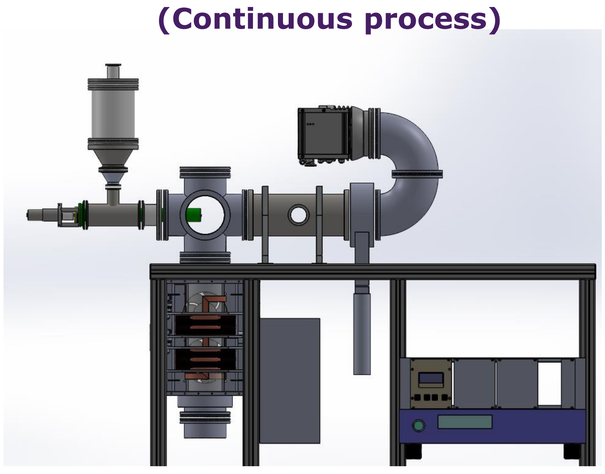
- **Any nature (metals, oxides, carbides, ceramics, polymers …)**
- **Any morphology**
- **Any particles size**

Plasma treatment systems

Magnetron Rotating Drum Reactor (Batch process)



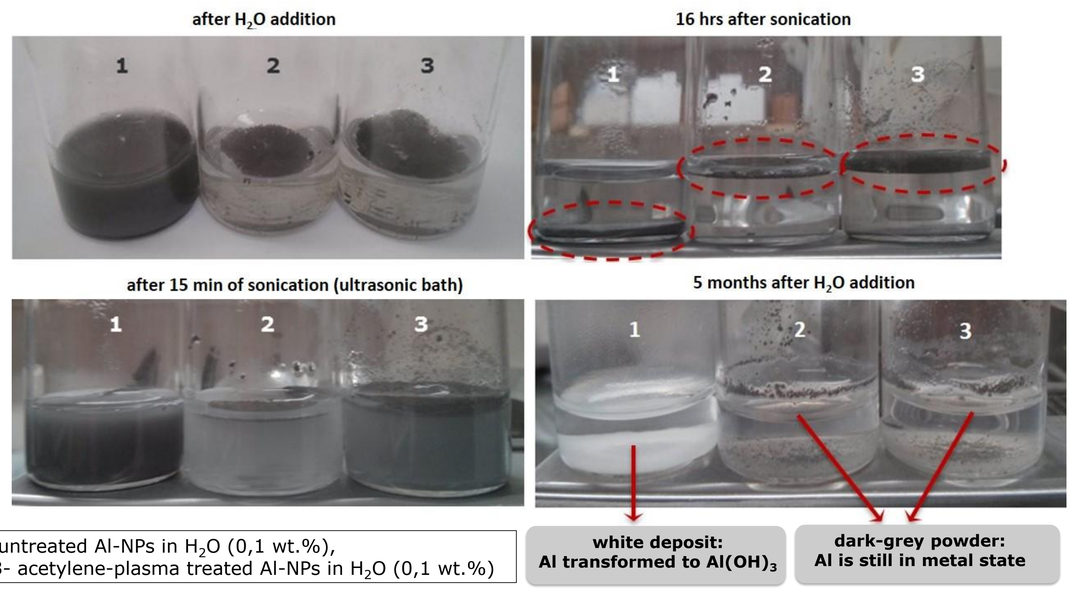
RF Gravitational Reactor (Continuous process)



- **Batch or continuous process, 100 g per batch, kg possible**
- **Variety of gaseous precursors**
- **Metal-based functionalization**
- **Continuous powder mixing during treatment**

Coated particles with new functional properties

Protective impermeable coating

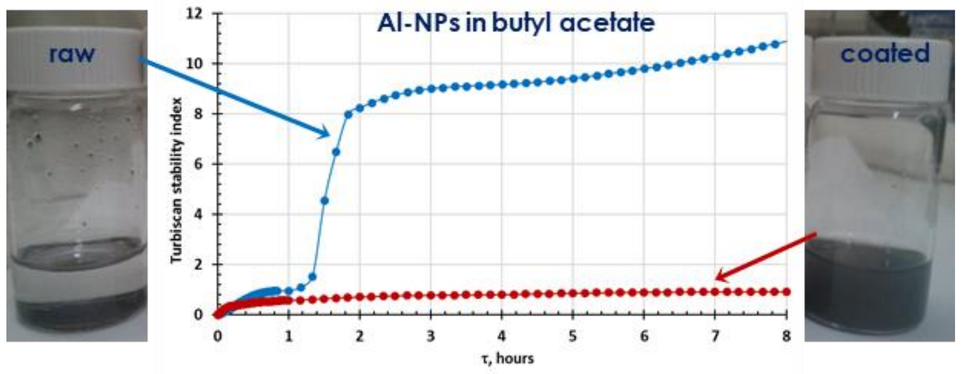


1- untreated Al-NPs in H_2O (0,1 wt.%),
2,3- acetylene-plasma treated Al-NPs in H_2O (0,1 wt.%)

white deposit: Al transformed to $Al(OH)_3$

dark-grey powder: Al is still in metal state

Improved stability in solvents/matrices



Destabilization kinetics measured with using of multiple light scattering analyser (Turbiscan)

Conclusions

Low-pressure plasma treatment is the effective method to create an **universal coating of powder materials with different morphology, particles size and composition**. Plasma coating allows **controllable modification of surface properties** of nano- and micro-particles (**hydrophobic/hydrophilic properties**) or creation of **impermeable protective layer**. Surface modification results in **improved dispersion and stability** of nano- and micro-particles in solvents and polymers.

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