RATIONAL DESIGN OF ENGINEERED MATERIALS FOR DIRECT INK WRITING

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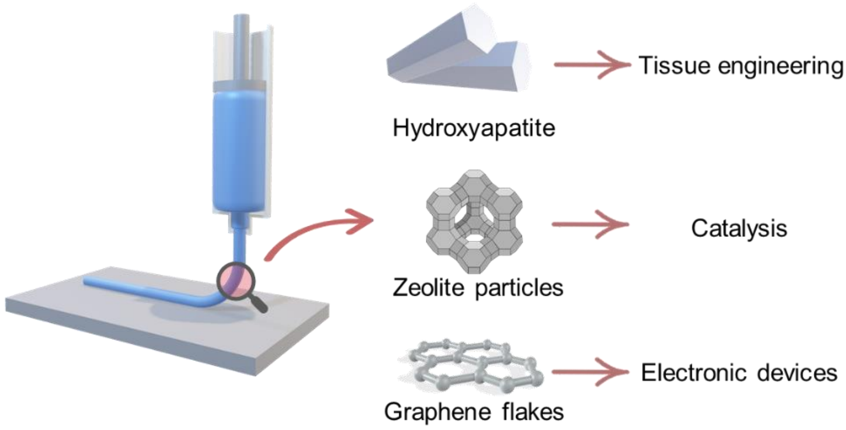

In the last few years, additive manufacturing is gaining increasing attention for the advantages it offers with respect to traditional techniques, such as rapid prototyping and versatility in complex shapes production. For this reason, 3D printing of traditional materials, such as polymers, is well established and largely studied. Differently, printing techniques of micro- or nanometric materials (e.g. graphene, hydroxyapatite, zeolites) are less analysed and optimized, even though many micro- and nanoparticles possess functional properties of great technological interest that would be highly beneficial for large-scale applications in electronics, tissue engineering, or catalysis.[1] The main challenge is the development of a printable ink, containing a high particle load, which allows to print a coherent monolith without affecting the functionality of the particles.

Among others, the Direct Ink Writing (DIW) technique is deemed to be one of the most versatile and suitable for the purpose. DIW consists in the extrusion at room temperature of a printable, particle-containing suspension through a moving nozzle. The desired shape is obtained through a layer-by-layer deposition and subsequently consolidated by controlled drying and sintering.[2] Despite the increasing diffusion of this technique, reliable design criteria for materials printable by DIW are still missing and the ink production still relies on the operator expertise.

So, the first goal of the project is the definition of theoretical and empirical criteria that correlate materials behaviour with their printability, in order to optimize the design of the inks. Printability is generically defined as the ability of a material to be extruded through a nozzle without clogging, with the aim of creating a continuous filament of constant section. A printable filament must maintain its shape under the action of capillary forces due to the contact with the other filaments and to the force of gravity.[3] Rheology has been individuated as the main tool to quantify these features. With the aim of defining printability criteria and optimizing the technology, different model systems are developed and analysed.

The second goal is the realization of 3D printed structures: this step involves the selection of the most relevant process parameters and the analysis of their effect on the product features, such as its surface texture or shape resolution. Moreover, proper consolidation strategies will be investigated in order to provide the structure with mechanical coherence and stability.

Finally, the as prepared structures will be tested in order to verify that the functionality of the printed particles is still preserved after the printing process: as an example, zeolites will be 3D printed in order to manufacture filters for pollutants removal from gaseous streams, that could be applied for the production of catalytic converters. Other 3D-printed structures will be applied as reactors, in order to exploit zeolites catalytic properties while enhancing fluid dynamic features through a selected design of the products.

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References

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