From Glass-phases to Nanostructures: Alternative Precursors to Metal Nitrides and Carbides

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Nanomaterial chemistry can be surely considered a new land of science, where metals become harder, ceramic more ductile or new properties such as plasticity or catalytic activity can be shown simply by reducing the material sizes. As a consequence, every known-material possesses additional potentials and further application fields. In this respect, there is a special interest concerning metal carbide and nitride nanostructures (MN/MC), which already as a bulk material possess special features (hardness, high wear resistance, electrical conductivity, magnetic properties, etc.), which make them suitable for a variety of applications.

Recently, combining a novel sol-gel process with a classical carbothermal reduction nitridation, we set-up easy and versatile pathways for the synthesis of these synthetically challenging materials by employing suitable N/C sources (from small molecules such as urea, to biopolymers such as gelatin), which also act as stabilizing agent. A common denominator of these procedures is the use of glass-like starting materials, which allow addressing a broader range of compounds, compared to classical solid powder precursors. This starting glass is processable and can be transferred into a variety of binary or ternary MN/MC nanostructures of high crystallinity and definition. The mesoscopic morphology can be controlled from mere spherical nanoparticles towards more complex structures such as fibres, wrapped nanosheets (fig.1) or replicas of leaf veins. This flexibility of shape control is possible without loosing simplicity, sustainability and reliability of the process.

Figure 1. a) glass-starting material and b) corresponding final solid powder of Fe₃C. In c) SEM image of the corresponding Fe₃C nanostructures (scale bar 1μm).