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Opinion

Nano-chemistry: The Toolbox for Nanoparticle Based Diagnosis and Theraphy

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The direction for synthetic chemistry that focuses on the approaches to building new materials form the fundamental building units of atoms and molecules is regarded as nano-chemistry. In the framework of nanomedicine, new freedoms can be proposed with the help of nano-chemistry approaches in order to create nano-pharmaceuticals for theraphy and nanoimaging probes for diagnostic. Nanoparticles with different functionalities can be created by tuning their size, shape, surfaces, interfaces, and constituents with the aid of nano-chemistry approaches. Nano-chemistry has provided the opportunity to weaken the boundaries between the disciplines and connect them globally. As already depicted by Niemeyer in the beginning of this century "chemistry is the central science for the development of applied disciplines such as materials research and biotechnology" [1]. In today's research, nano-chemistry has contributed for diminishing the defined boundaries of biology, chemistry, physics, material, medicine, pharmacy for the benefit of nanomedicine research mainly by providing nanoparticles for medicine. By this way, innovative nanoparticle designs can address the challenges and shortcomings faced by traditional medicine. In this context, nano-chemistry approaches help to form a nanoparticle-based diagnosis and theraphy.

In the late 1950s, Nobel physicist Richard Feynman can be said to create a huge interest for the development of bottom-up strategies, as he, in his famous lecture "There's plenty of room at the bottom" put forth the idea of being able to control the manufacturing of materials at the atomic level. In bottom-up approaches, the self-assembly of atom or molecules is used to form nanoparticles with the gas and liquid phase techniques which involve strategies from today's nano-chemistry. In liquid phase techniques, wet chemistry approaches such as sol-gel, micro-emulsion, spray pyrolysis methods are used to obtain nanoparticles. In gas phase techniques physical and chemical vapor deposition approaches are employed. Bottom-up approaches generally offer good control of both physical and chemical features of the synthesized material, which constitutes the most fundamental aspect of nanomaterial fabrication. More specifically the liquid phase techniques allow the possibility of tuning size, shape and surface functionality control as well as prevention of particle aggregation since the other organic molecules can be incorporated into the synthesis protocol during the preparations. The flexible synthesis protocols in the liquid phase techniques play an important role to create modular nanoparticle designs which is beneficial to create solutions for the challenges in nanoparticle-based biomedical applications.

In the current status of in- clinics imaging probes are mainly organic molecules or metal-organic compounds [2]. However, the utility of molecular probes is restricted due to their physical and physiological properties. The nanoscopic imaging probes have already made significant progress in overcoming limitations such as their photostability as well as multiplexing problems of molecular probes associated with conventional, molecular imaging agents [3]. Several imaging techniques get benefit from the nanoparticle-based imaging probes including magnetic resonance imaging (MRI), computed tomography (CT), positron emission tomography (PET), single photon emission computed tomography (SPECT), and optical imaging (OI) methods such as those based on luminescence or fluorescence. Especially the size-dependent tunable properties make them superior and indispensable in many areas of human activity. In the design of nanoscopic imaging probes nano-chemistry approaches employed at different stages. Physical properties, surface modifications, and composition of porous and nonporous nanoparticles can be tuned in order to make them powerful tools for imaging [4]. In this way, not only better imaging performance is provided also the great versatility of multimodal, stimuli-responsive, and targeted imaging can be obtained with different design strategies (e.g. core-shell structure, in situ synthesis and post-synthesis approaches). In recent developments stimuli-responsive properties could be implemented or improved with the aid of nano-chemistry approaches for instance, the cell labelling efficiency of magnetite nanoparticles have been increased with the silica shell coating around with the liquid phase synthesis approaches and further surface modifications with nano-chemistry approaches (i.e., polymerizations on nano surfaces) have magnetically enhanced cellular uptake [5]. With

the exploitation of multifunctional nanoscopic imaging probes to research, the constructions of personalized medication theranostic nanomedicine can be provided in the future.

The nano-pharmaceutical designs deal chiefly with the development of nano-sized drug delivery systems, where the nano-the material serves as the drug carrier. Those nano-constructs are expected to guide drugs to the desired site of action with increased precision (targeted drug delivery) and provide controlled release, enhance drug solubility and rate of dissolution, improve the therapeutic index, reduce the dose needed, increase the drug stability, promote the transport across biological barriers, decrease drug resistance, and reduce toxicity and immunogenicity [6]. In providing the mentioned benefits the size, shape, morphology, surface chemistry of nanoparticle play a vital role. Nano-formulations can be constructed from organic, inorganic synthetic materials and bio-origins. Nowadays, hybrid nanomaterials are considered as favourable contracts to new drug-delivery mechanisms and to attain multifunctional properties for the drug delivery. Hybrid nanoparticles offer a vast array of advantages by combining the unique properties of the organic and inorganic counterparts [7]. Now a day's nano-scaled carriers are increasingly complex systems could be possessing sophisticated release mechanisms with different endogenous (pH, temperature, biochemical reactions) or exogenous (light, magnetic field, ultrasound) stimuli responses which is mainly constructed with the aid of post/in-situ synthesis nano-chemistry approaches. For instance, drug release from the nanocarriers can be tuned with by altering the desorption of nanoparticle surface bound drug, erosion of the nano construct matrix and also diffusion profile of the drug our from the nanoparticles. In the intracellular drug delivery approaches, the penetration through the biological barriers has vital importance. The fine tunings at the interface of biological barriers and nanoparticles can be obtained by tuning the surface chemistry of nanoparticles with nano-chemistry approaches. By this way, superior effects for the penetration of nanoparticles through the physiological, pathological and cellular barriers can be obtained. For instance, the net negatively or neutral charged surface grafting prepared via nano-chemistry approaches lead relatively less non-specific interactions with negatively charged biological barriers whereas a slightly positive charge on the nanoparticle surface could be used to facilitate cellular uptake. Furthermore, active, passive or physical targetability for the therapeutics can be obtained by tuning the size, surface chemistry, and constituents of the nano-pharmaceutical designs.

All in all, any characteristics of nano-diagnostics and nano-pharmaceuticals can be controlled by using the nano-chemistry approaches as the toolbox in order to provide precision for powerful imaging and effective drug delivery to the desired sites. It is well-accepted 'Nano' has already shuffled the deck of medicine and it is continued with the sophisticated nano-chemistry approaches. In order to provide fasten the clinical translation of the research findings interdisciplinary interactions span from the molecular interactions between organisms and regulatory levels should be pursued.

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