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Nanoparticles and Sound: A Mini Review

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Abstract

Nanoparticles are nano-scale materials that have gained profound interest due to essential properties like small size which makes them suitable for a wide range of applications. Sound, as applied to these nanoparticles is an emerging field with growing interest by researchers. This mini-review article discusses methods involved in sound and nanoparticle research, whiles highlighting on their applications in diverse areas like drug – delivery studies. This overview briefly assesses general areas in this scope to suggest possible future research studies and applications.

Keywords: Anthropogenic; Nanoparticles; Ultrasound; Sonosensitizers; Biomaterials; Tissue– mimicking phantoms; Drug delivery

Introduction

Nanoparticles are particles that range from 1-100nm in diameter [1]. They can be naturally occurring or possess anthropogenic sources. These particles have been in use since days of old, but the advent of new technology has made it possible for them to be observed [2]. The particles small size and high surface area contributes to its peculiar physicochemical properties such as reactivity, which makes them useful in this advancing scientific age [3]. They are used in a wide range of applications in medicine: drug delivery, fluorescent biological labels [4], and everyday life: surface treatment of fabrics and lightweight vehicles [5]. Sound is a wave that travels through a medium. It is created when a vibrating particle transmits its energy of motion to particles in its surroundings, generating a pressure wave. Sound is a part of everyday life and has proven not only be useful in music but a necessity in nanoparticle analysis. It interacts with materials as the latter absorbs, reflects, refracts and dissipates sound energy. An example is the use of music in altering water structure to generate different patterns of the same water molecule [6]. An aspect of sound – the ultrasound – which constitutes high frequency sound waves is safe, non – invasive and has its usage in medical diagnosis, submarine detection [7-9] and other ultrasonic endeavors in fields like material science and food technology [10,11]. This review evaluates the different methods in which sound waves are used in nanoparticle modification for healthcare and industrial applications. It also discusses the current research trends in the scope of sound in nanotechnology and highlights the gaps that need to be addressed.

Synthesis and Applications

In drug delivery, nanoparticles produce sound during movement to the target site, reducing their speed due to the sound – pressure interaction. In analyzing this, the impact of sound in the early developmental stages of nanostructures was analyzed. A composite nanostructure was developed and lower frequencies from various ultrasound machines were applied resulting in fast movement of particles [12]. The results were confirmed with advanced biomedical imaging techniques. Progress has been made in this scope. Here, ultrasound is utilized in studying on the nano scale, in lipid shell drug interactions in real time. Functionalized nano-coated drugs can be fabricated with sound. Low frequency ultrasound in drug release analysis produces cavitation, which leaves the focal points of delivery in the cell destroyed. A different approach, involving smart nanoparticles and higher ultrasound frequencies is employed. In this instance, a focal point of the target cell's lipid membrane bilayer reacts with the sound waves, whiles the membrane barrier enclosing the nano-coated vesicle releases the drug and then the cell membrane heals [13,14]. In nano-assembly of particles, their distinct physicochemical characteristics can be affected by electrostatic interactions to generate fairly – fragile composites. The use of sound in joining nanoparticles can offset this drawback to produce functional and durable composites. Phosphate bonded mesoporous particles have been produced by using ultrasound on processed nanoparticles [15]. The integrity of the nanostructures was kept by this technique. Moreover, mechanically fabricated composites with nanoparticles are on the rise. Nano- sieves have been made with acoustic excitation of particles. The interaction of sound with a particle affects the surrounding particles and can draw them together. Sound waves were applied to a packed bed of micro-particles and nanoparticles were drawn onto it [16].

Sound has been used to study nanoparticle behaviour. A thermal sono-sensitivity of nanoparticles with tissue–mimicking phantoms has been carried out. For temperature increase, density and attenuation, materials doped with the nanoparticles were heavier than those doped with the micro-particles. The reverse is the case when considering backscattering coefficients. Nanoparticle tissue–mimicking phantoms absorbs much more ultrasound thus, generates much more heat than micro–particle tissue–mimicking phantoms [17]. Its relevance can be seen in cancer studies as they improve sound efficiency for treatment. Magnetic nanoparticles were considered due to its vast use in biomedicine. Thermal doses affect the shape of lesions as sonosensitizers contribute to the heating during ultrasound [18].

Conclusion

Nanoparticles possess diverse properties which are essential to various research fields [19,20]. This review highlighted the physics of sound and nanoparticle perspective in fabrication, modification and synthesis which can be utilized in broader applications than those in the literature.

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