

The Non-thermal electromagnetic arenas to activate On-Demand drug release from High-Tm Magnetoliposomes- Stefania Petralito - University of Rome, Italy

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Nowadays the researches and development in the field of Nanotechnology has provided a source of novelty in various ground. The yields of nanoscience and nano particles are no exception. Nanoparticles are simply particles in the nanosize range (10–9 m), usually <100 nm in size. Due to their very tiny size and surface area characteristics, they exhibit unique electronic, optical, and magnetic properties that can be exploited for drug delivery. Also called as nanovectors in drug delivery field, they are challenging new tools for controlled release of drugs because they can satisfy the two most important criteria for successful therapy, ie, spatial placement and temporal delivery. There are unique techniques have been established on the basis of the interaction between Magnetic Nanoparticles and liposomes for heavy metal detection, interaction between these nano sized materials with cells or other biomolecules have enormous biomedical application including cell imaging, bacteria identification, detection of cancer and drug delivery. A new system for the precise delivery of the pharmaceutical drugs has been established by a team of chemical engineers using modern nanoparticles inserted in a liposome which can be activated by non-invasive electromagnetic fields.

Energy transfer process can occur by the deactivation of donor and the formation of acceptor in an electronic excited state by two discrete mechanism. One is FRET, which is mainly occur through-space mechanism: which requires the overlap between the emission spectra of donor and absorption of the acceptor and obtained from the long-term dipole-dipole interaction between a donor molecule in the excited state and an acceptor molecule in the ground state. Other one is DET, which occurs through-bond mechanism

Magnetic nanoparticles with superparamagnetic properties have attracted increased attention for applications in biomedicine, as they exhibit a strong magnetization only when an external magnetic field is applied. Magnetoliposomes (MLs) are the combination of liposomes with encapsulated magnetic nanoparticles. These hybrid nanocarriers have been showing significant biomedical application possibilities. However, it is essential that nanoparticles exhibit superparamagnetism, this causes nanoparticles to become susceptible to strong magnetization. When the magnetic field is applied, they orient toward this field, but do not retain permanent magnetization in the absence of magnetic field. SPIONs are small synthetic γ -Fe₂O₃ (maghemite), Fe₃O₄ (magnetite) or α -Fe₂O₃

(hematite) particles with a core ranging from 10 nm to 100 nm in diameter. In addition, mixed oxides of iron with transition metal ions such as copper, cobalt, nickel, and manganese, are known to exhibit superparamagnetic properties and also fall into the category of SPIONs. However, magnetite and maghemite nanoparticles are the most widely used SPIONs in various biomedical applications.

The morphology of Fe₂O₃ nanoparticles has been known to be affected by several factors, including the reaction conditions and chemicals involved. In the presence of surfactants with bulky hydrocarbon chain structures, like oleylamine and adamantane amine, the steric hindrance exerted by surfactants has been shown to affect the shape of growing crystals of iron oxide during synthesis.¹¹ The shape of magnetic nanoparticles has not been extensively studied as far as its effect on biodistribution of SPIONs is concern.

SPIONs have an organic or inorganic coating, on or within which a drug is loaded, and they are then guided by an external magnet to their target tissue. These particles exhibit the phenomenon of “superparamagnetism”, ie, on application of an external magnetic field, they become magnetized up to their saturation magnetization, and on removal of the magnetic field, they no longer exhibit any residual magnetic interaction. This property is size-dependent and generally arises when the size of nanoparticles is as low as 10–20 nm. At such a small size, these nanoparticles do not exhibit multiple domains as found in large magnets; on the other hand, they become a single magnetic domain and act as a “single super spin” that exhibits high magnetic susceptibility. Thus, on application of a magnetic field, these nanoparticles provide a stronger and more rapid magnetic response compared with bulk magnets with negligible remanence (residual magnetization) and coercivity.

This superparamagnetism, unique to nanoparticles, is very important for their use as drug delivery vehicles because these nanoparticles can literally drag drug molecules to their target site in the body under the influence of an applied magnet field. Moreover, once the applied magnetic field is removed, the magnetic particles retain no residual magnetism at room temperature and hence are unlikely to agglomerate (ie, they are easily dispersed), thus evading uptake by phagocytes and increasing their half-life in the circulation. Moreover, due to a negligible tendency to agglomerate, SPIONs pose no danger of thrombosis or blockage of blood capillaries.

The magnetic properties of super paramagnetic iron oxide nanoparticles (SPIONs)-based magnetoliposomes allow for alternative therapies through magnetically controlled drug delivery and hyperthermia. In this way they can be viewed as trigger-responsive carriers as they have the potential to act as "remote switch" that can turn on or off the effects of the therapeutics, based on the presence or absence of the stimulus. Recently, a pilot study has demonstrated the feasibility of smart controlled delivery through a magnetic field with intensity significantly lower than the ones usually reported in literature. In this way, a controlled release has been obtained through a magneto-nanomechanical approach without any macroscopic temperature increase. Specifically, signals generated by non-thermal alternating magnetic fields (AMFs) or non-thermal pulsed electromagnetic fields (PEMFs) were applied to high-transition temperature magnetoliposomes (high-T_m MLs) entrapping hydrophilic SPIONs, proving to be interesting and promising stimuli-controlled drug delivery systems