Biohazard Detoxification Using Magnetic Nanoparticles

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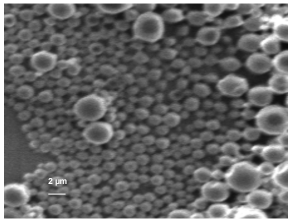
Research Goal: Development, design, and demonstration of a novel, integrated system based on magnetic nanoparticles for selective and rapid removal of biological, chemical, and radioactive biohazards from humans.

Approach: The system provides a novel treatment strategy for detoxifying blood-borne radionuclides in humans. Key features of the technology are:

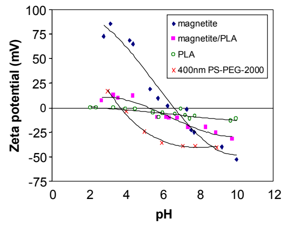
- Biocompatible magnetic nanoparticles that bind the radioactive toxins within the bloodstream and
- A compact, external magnetic separator that sequestrates the toxin-loaded magnetic particles from the body.

The magnetic nanoparticles are provided in tiny ampoules, and the process can be self-administered.

Biocompatible Magnetic Nanoparticles

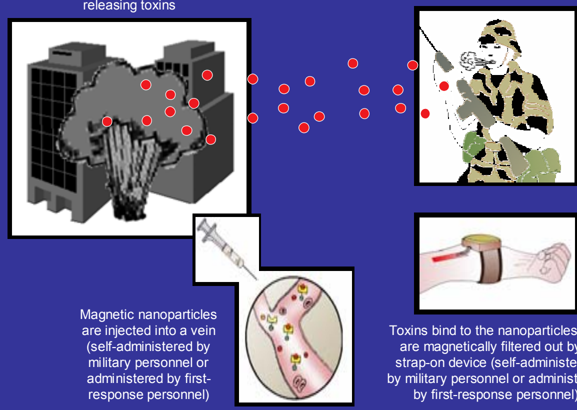


Biodegradable particles such as these poly(lactic-glycolic acid) nanoparticles carry surface receptors to remove specific targets from the blood. Magnetic properties are conferred by magnetic nanocrystals imbedded within the polymer spheres.



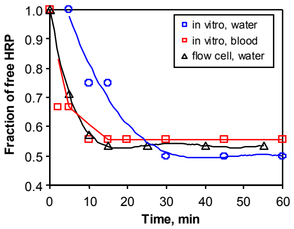
The nanoparticles must reduce immune system response and maintain free circulation. One of the properties governing immune system response is surface charge. Near-neutral charge is the goal for the resulting nanoparticles. This plot shows the surface charge for some materials used to synthesize the magnetic nanoparticles.

Designed for Self-Administered, In-Field Use



Following a radiological event, exposed soldiers can self-administer nanoparticles by injection and then strap on a magnetic filtration unit that attaches to the arm by vascular access to remove the toxin. The nanoparticles are injected directly into the bloodstream. Anti-toxins (e.g., antibodies, radionuclide extractants, receptor mimetics) attach to the nanoparticle surface, selectively capture toxins, and form nanoparticle-toxin complexes. When enough time has passed to allow the formation of the nanoparticle-toxin complexes, the soldier or first-response personnel inserts a catheter into an artery or vein and the magnetic filtration system is connected to an artery or vein where the nanoparticles-toxin complexes are magnetically filtered from the blood.

We established a working rat model to study the biodistribution, pharmacokinetics, toxicology, and magnetic separation of prototype nanoparticles and establish the magnetic filter efficacy.



In-vitro tests of model magnetic nanoparticles showed that 50% of biotinylated horseradish peroxidase can be removed with first-generation biostabilized nanoparticles.

This multidisciplinary project involves scientists and engineers from a federally funded research laboratory and two universities. The involvement of industrial firms from the onset of the project will facilitate and expedite commercialization.

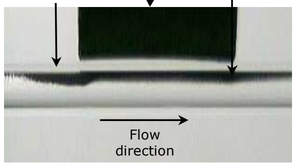
Program Management
Michael D. Kaminski, ANL
Axel J. Rosengart, UC

Nanoparticle Synthesis
Biostability (ANL)
Biodegradability (ANL)
Receptor density (ANL)
Scaleup (Cortex, Inc.)
Commercialization (Cortex, Inc.)

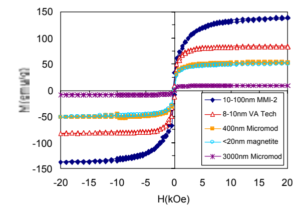
Extracorporeal Magnetic Filter
Medical efficacy (UC)
Prototype design (Illinois Institute of Technology, IIT)
Prototype fabrication (ANL/ITT)
Magnetics (ANL)
Commercialization (Murray, Inc.)

Animal Testing
Protocol (UC/ANL/IIT)
Animal care (UC)
Surgery (UC)
Pathology (UC)

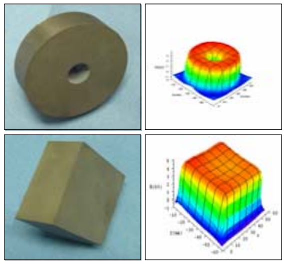
Compact, External Magnetic Separator



The nanoparticles are magnetically separated from the blood in microchannels that pass through a strong magnetic field gradient.



The nanoparticles must be highly magnetized. This plot shows the magnetization of various materials being tested under this program.



Small, powerful permanent magnets will be surveyed for suitability within the compact magnetic separator. The plots of the magnetic fields will be used as input into an in-house magnetic field-fluid flow computer model.

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