Argonne NATIONAL LABORATORY | Technology Development & Commercialization

Magneto-optic Biosensor Using Bio-Functionalized Magnetic Nanoparticles

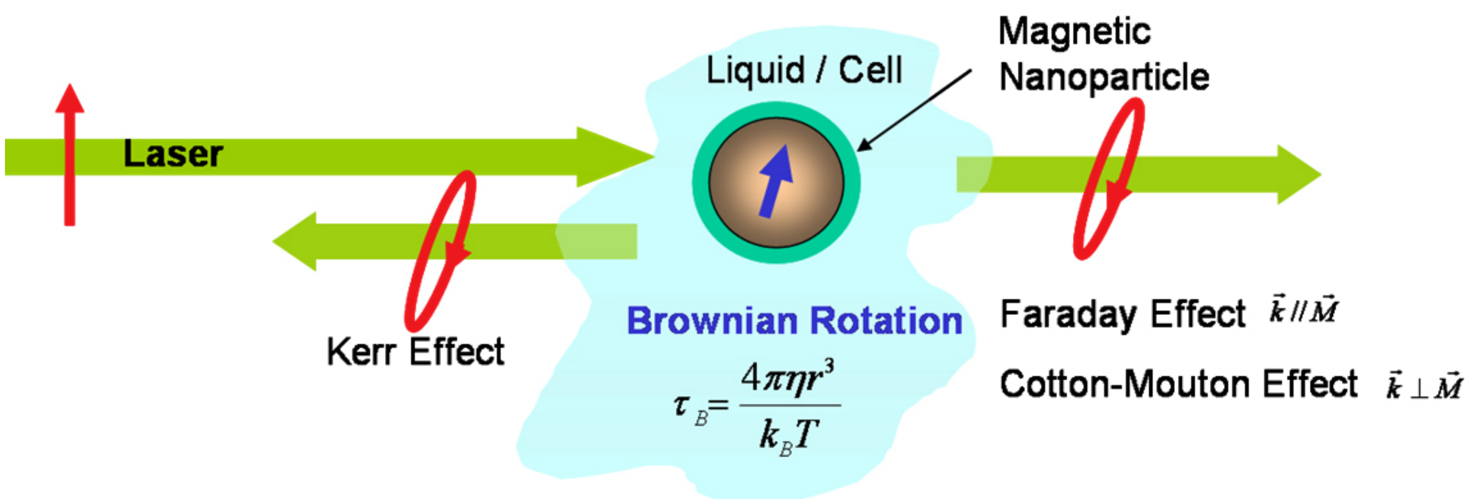
Magnetic nanoparticles are leading to more sensitive, rapid and cost-effective biological sensors. These sensors can be used for a variety of applications, including the detection of medical conditions and bioterrorist threats.

Technology Description

Recently there has been an increased interest in magnetic nanoparticles with biologically relevant ligand coatings. These nanoparticles can have many biological and medical uses, including targeted drug delivery, magnetic separation, hyperthermal treatment and biosensors.

Researchers at Argonne National Laboratory have developed a magneto-optic biosensor that uses bio-functionalized magnetic nanoparticles. The long-range interaction between magnetic nanoparticles and an external magnetic field enables manipulation and sensitive detection of those particles for improved biosensors. The process involves applying a time-varying external magnetic field and a linearly polarized incident laser light to a suspension of magnetic nanoparticles. The resulting transmitted or reflected light and its polarization will be recorded with a suitable photodetector. This allows for the determination of the Brownian relaxation time, which may indicate hydro-dynamic radius changes upon chemical binding of the target to the magnetic nanoparticles.

Argonne's magneto-optic biosensor can be used to measure either local rheological properties, since the Brownian relaxation time is proportional to the viscosity, or chemical binding events, which result in an increase of the hydro-dynamic radius.



This schematic of the magneto-optic detection system illustrates a magnetic nanoparticle stimulated by external time-varying magnetic fields. The dynamic magnetic response is detected by either the transmission (Faraday or Cotton-Mouton Effect) or reflection (Kerr Effect) of polarized light. The time-dependence of either transmission or reflection can help determine the local viscosity or changes to the hydro-dynamic radius.

The latter can be used as a research tool for investigating binding kinetics in real time or as a custom-designed sensor for specific target molecules. By optimizing the magnetic nanoparticle with respect to the desired target molecule, this approach can be adapted to a wide variety of targets, such as specific molecules, proteins, and disease markers. At the same time, the ability to directly investigate reaction kinetics enables the examination of how different chemical/biological environments influence the binding process.

Potential Benefits

The Argonne-developed biosensor is unique because of its ability to enable more rapid and sensitive detection. Magnetic modulation of ferromagnetic particles in liquid can increase the signal sensitivity by several orders of magnitude. In addition to improvements in speed and sensitivity, the biosensor is potentially more cost-effective than existing technologies. Its simplicity also allows relatively untrained personnel to operate the sensor.

The shelf-life of magnetic nanoparticles can essentially be infinite, which is beneficial compared to other biosensing methods that use fluorescent and radioactive materials. The magneto-optic biosensor displays many other advantages, including the simplicity of mix-and-measure, the ability to obtain information beyond the biochemical affinity and straight-forward integration with microfluidics.

Biosensors have many potential commercial applications. For bioterrorism and environmental needs, they can be used for remote sensing of airborne bacteria and detecting water toxins and contaminants. In the medical field, biosensors have many uses, including drug discovery and evaluation and glucose monitoring in diabetes patients.

The possibilities increase with Argonne's improved biosensor. This technology can be used to detect and monitor DNA hybridization, DNA/RNA-protein, protein-protein, and protein-small molecule interactions. With these capabilities, the biosensor could be attractive for research purposes and diagnostic applications, such as detecting disease-causing bacteria and viruses. The potential also exists for *in vitro* applications, such as the detection of local temperature and viscoelasticity within inter-cellular environments or possibly even *in vivo* immunoassays.

Technology Area: Medical device
Product: Medical and biological detection tool
Development Stage: Prototype
Primary Inventors: Axel Hoffman and Samuel Bader
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Contact: Technology Development and Commercialization
email: partners@anl.gov