108

Exploiting dynamical magnetization for oligonucleotide detection in biological fluids

Author: Francisco Jose Teran[1]

Co-authors: Sedef Ozel-Okcu[2]; Rebeca Bocanegra[1]; Maria Jesus Valle-Pastor[1]; Alejandro Venegas-Gomez[1]; Idoia Mikez-Alonso[3]; Aiztiber L. Cortajarena[3]

[1] *iMdea Nanociencia*
[2] *Nanotech Solutions*
[3] *CIC biomaGUNE*

In recent years, magnetic nanoparticles (MNPs) have attracted considerable attention in applied research because of their unique dynamical magnetization properties. One of their most promising applications is biosensing, where biomolecular recognition events are transduced through changes in magnetization dynamics. Recent studies have reported a novel methodology for protein detection based on variations in AC magnetization cycles of receptor-functionalized MNPs in the presence of target proteins [1]. The combination of MNPs with AC magnetometry offers several advantages for biomolecular analysis, including label-free detection, simple operation, and the absence of optical interference in biological buffers.

Here, we explore the potential of commercial cobalt ferrite MNPs for DNA detection. Streptavidin-conjugated magnetic nanoparticles (SA-MNPs) serve as versatile platforms for sensing biotinylated single- and double-stranded DNA molecules down to picomolar concentrations in phosphate-buffered saline (PBS). Surface modification resulting from the specific interaction between SA-MNPs and DNA significantly alters nanoparticle diffusion, which directly affects their dynamical magnetization. Based on this principle, we developed a magnetic detection methodology for direct sensing of single- and double-stranded DNA in saline buffer.

Biotinylated DNA strands with lengths ranging from 10 to 88 base pairs were incubated with SA-MNPs for one hour at 25 ℃ under gentle mixing. AC magnetization cycles were measured both before and after DNA binding over excitation frequencies ranging from 1 to 350 kHz. The detection sensitivity was found to depend strongly on nanoparticle concentration, the number of streptavidin molecules per particle, and the AC magnetic field conditions. DNA binding results in multiple DNA molecules attaching to individual SA-MNPs, producing diffusion changes related to DNA length, hybridization state, and concentration. The AC hysteresis-loop area changed by as much as 23% for double-stranded 44 bp DNA at a concentration of 100 nM. Furthermore, single- and double-stranded DNA molecules produced distinct dynamical magnetization signatures depending on their length, concentration, and hybridization state. These results demonstrate that AC magnetometry provides a simple and powerful approach for studying DNA biophysics through straightforward magnetization modeling of individual SA-MNPs [2].

Funding

The authors acknowledge financial support from the STRIKE Project (Grant Agreement No. 101072462) funded by the European Union Horizon Europe MSCA Doctoral Networks programme.

References

[1] Sanz de Diego et al., *Nanoscale*, 16 (2024), 4082.
[2] Palacios-Alonso et al., *Nanoscale*, 17 (2025), 12963.

Type:
Oral