Boca Scientific's Toolkit of Magnetic Beads Can Fix a Range of Biomolecular Separation Problems

What are magnetic silica beads?

Magnetic beads can isolate a diverse range of biomolecules and have several applications in life sciences, including the purification of nucleic acids and proteins. Magnetic beads contain a magnetic core covered by a surface. Beads of different sizes and surface chemistries have their own benefits depending on the application. Regardless of their size or surface functionalization, the steps involved in using magnetic beads remain the same. First, the beads form a suspension with a complex mixture without a magnet and bind to the molecule of interest. Unwanted material can be removed using washing steps. Then, in the presence of a magnet, the beads display magnetic behaviour and are drawn towards the magnet causing the beads to sediment, resulting in the isolation of the biomolecule of interest.

Boca Scientific work with MoBiTec and Isohelix to offer a wide range of magnetic beads of different sizes and coatings. Protocols employing magnetic beads require fewer steps than traditional methods, such as precipitation and centrifugation steps, which are laborious and time-consuming. Also, magnetic bead protocols are suited to low-technology environments, as an end user only needs magnetic beads and a magnetic separator. Boca Scientific's wide range of magnetic separators is adapted to experimental setups using either tubes or microplates.

How can magnetic beads be used to isolate nucleic acids?

Boca Scientific provide several solutions for isolating DNA from different sources. Boca Scientific's MagSi-DNA magnetic beads bind to nucleic acids to:

- Isolate genomic, mitochondrial, or viral DNA
- Isolate plasmid, or phage DNA
- Clean up DNA from enzymatic reactions (restriction digestions, ligations) or chromatin immunoprecipitation (ChIP) procedures.

The magnetic core of the MagSi-DNA beads is coated with either silica or carboxylic acid, which determines the buffer conditions of the experiment. For silica and carboxylic acid coatings, chaotropic buffers can be used, which disrupt hydrogen bonds and bridge the negative charges on the nucleic acid and bead surface with their divalent cations. This mechanism is reversed by using a low-salt buffer to elute the DNA from the beads. Carboxylated magnetic beads are compatible with

protocols employing polyethylene glycol precipitation (PEG)-based buffers or pH changes that affect the binding of the biomolecule to the bead surface.

Another type of silica magnetic bead is the MagSi-DNA mf beads (300 nm bead size). Unlike superparamagnetic beads, these beads have ferrimagnetic properties and retain their magnetic moment even after removing the magnetic field. The beads' large surface area and the minimal adhesion with plastic make these beads ideal for nucleic acid purification and isolation in microfluidic and chip-based genomic setups. The beads are well-suited to fast protocols as beads typically collect within 10 seconds in a magnetic field. Baumgartner and co-authors recently used the MagSi-DNA mf Beads (cat. no. MD0200010002) to capture the pathogen DNA and carry it through microfluidic chambers for automated PCR detection. The authors used the beads to successfully achieve automated microbial screening of bacteria that cause oral diseases (Baumgartner et al., 2021).

Boca Scientific offer a solution for the fast and cost-effective extraction of total nucleic aids for pathogen detection from a variety of human samples — taking less than 30 mins to prepare 96 samples. The MagSi-NA Pathogens DNA/RNA Purification Kit (MDKT00210096) provides all the materials needed to extract DNA and RNA for qPCR based or any other enzymatic pathogen detection method. The kit produces high yields of total nucleic acids (Figure 1) from human samples, including serum/plasma, suspended stool, swab washes or swab transport media. The kit is amenable to small and high-throughput protocols and is compatible with liquid handling robots, such as the Hamilton® and TECAN®.

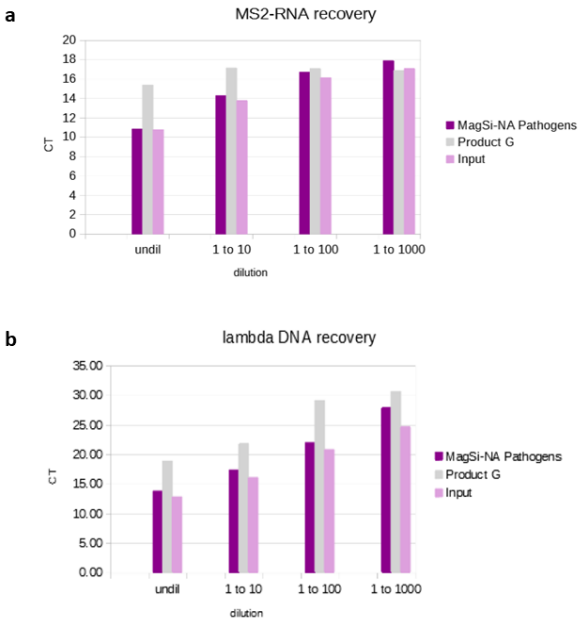

Figure 1. MagSi-NA Pathogens DNA/RNA Purification Kit (MDKT00210096) produces high recovery efficiencies for RNA and DNA viruses

a. Bacteriophage MS2 RNA recovery. Variable amounts of Bacteriophage MS2 RNA were spiked into human serum samples. MS2 RNA was detected using a qRT-PCR assay. High recovery rates were obtained with reference to the spiked RNA (Input) and in comparison to a competitive kit (Product G). **b**. Phage lambda DNA recovery. Variable amounts of lambda DNA were spiked into human serum samples. Lambda DNA was

detected using a qPCR assay. High recovery rates were obtained with reference to the spiked DNA (input) and compared to a competitive kit (Product G).

Immobilizing of peptides, proteins and glycoproteins onto nanoparticles using magnetic beads

MagSi-Tools are magnetic beads that can covalently bind peptides, proteins, nucleic acids and other molecules of interest depending on their surface modifications (Table 1). Important applications include solid phase separation. A critical parameter of the MagSi-Tools is the bead size, which determines the applicability to downstream applications. MagSi-Tools come in three bead sizes (600 nm, 1 µm and 3 µm). Smaller bead diameters take longer to sediment than larger ones, making them ideal for automated and high-throughput applications where slower sedimentation rates are needed, as shaking and mixing steps are not included in these protocols.

Table 1. Surface chemistries with the MagSi-Tools beads

Surface activation	Applications
Silica	Nucleic acid applications
Carboxyl	Immobilizing peptides, proteins and antibodies
Aldehyde	Immobilizing proteins
Amine	Immobilizing proteins
Sulfydryl	Immobilizing target cysteine groups, coupling to gold nanoparticles
Tosyl	Immobilizing peptides, proteins and antibodies
Hydrazide	Immobilizing glycoproteins, proteins and peptides
Epoxy	Immobilizing enzymes, proteins and peptides

Purifying antibodies and proteins using magnetic particles

Magnetic beads are ideal tools for meeting the growing demands of purifying and screening large numbers of antibodies. For research purposes, capturing antibodies allows the purification of the protein containing the antibody's epitope along with other precipitating proteins (with immunoprecipitation) or DNA (with ChIP), identifying biological complexes. Either Protein A (MagSi-Protein A) or Protein G (MagSi-Protein G) can be covalently bound to the surface of the magnetic bead. Protein A and Protein G binding to IgG subtypes vary depending on the species and Ig subclasses. Magnetic beads coupled with Protein A or Protein G are routinely used to achieve high yields of protein purification and antibody isolation. MagSi protein A and protein G beads are commonly used to immunoprecipitate and study protein and DNA complexes (Díaz-Hernández et al., 2015; Hjeij et al., 2014; Oppikofer et al., 2013).

Using magnetic beads for proteomic applications

The proteomic analysis of complex biological samples using mass spectrometry (MS) remains challenging. Following peptide digestion, salts and other components from samples that interfere with peptide ionization and add background to the mass spectra must be removed (Gundry et al., 2009). Magnetic silica beads coated with a weak cation exchange surface (MagSi-WCX) can remove clean-up samples before MS by binding to them based on their net surface charge. By reducing the complexity of proteins or peptides in a biological sample, these beads result in a higher sample coverage in MS analysis. A recent study used MagSi-WCX beads to simplify complex peptide

mixtures from urine samples before tandem MS to identify biomarkers for early chronic rejection of kidneys using the urinary proteomic profile (Hussien et al., 2020).

Another method to reduce sample complexity for MS is by fractionating samples according to their hydrophobicity. MagSi-Proteomics are magnetic silica beads coated with C4, C8 or C18 alkyl groups that fractionate proteins and peptides according to their hydrophobicity. The MagSi-proteomics C18 magnetic beads can be used to desalt and enrich samples by concentrating hydrophobic proteins and peptides from plasma and serum samples. The sample binds to the beads via hydrophobic interactions and can be eluted using mass spectrometry-compatible solvents, such as acetonitrile.

Magnetic beads solutions for isolating DNA from challenging sample types

Saliva is an attractive sample type as collection is non-invasive and can be self-collected. However, extracting DNA from saliva samples can be difficult as saliva samples are viscous, making it difficult to pipette between steps. Solvents are also needed to extract DNA. Boca Scientific offer DNA extraction isolations from GeneFix, which employs magnetic separation. The GeneFix Saliva-Mag DNA Isolation Kit eliminates the need for harmful buffers, solvents, columns and filtration equipment. Boca Scientific also provide DNA isolation kits (BuccalMag DNA Isolation Kit) that extract DNA from buccal swabs and are compatible and do not need additional plastic tubes, avoiding tube transfer.

Contact us for more information on our range of magnetic beads

Boca Scientific have an extensive range of magnetic beads that are optimized for a wide range of applications, from nucleic acid purification to protein and peptide separation.

Please contact us for more information about choosing the ideal magnetic separation solution for your application.

Tips and tricks for using magnetic beads

- Select a magnetic bead appropriate to your application and compatible with the buffer solutions used in the experimental protocol.
- When handling the magnetic beads, please follow the manufacturer's instructions carefully. You may need to wash the beads before use to replace the storage solution with the solution compatible with the protocol.
- Use the proper pipetting technique at all times (pre-wet the pipette tip, avoid air bubbles).
- For separation, ensure that the magnet is kept in the correct position relative to the sample holder. Boca Scientific have a wide range of magnetic racks compatible with Eppendorf tubes, PCR tubes and microplates (96-well and 364-well formats).
- Allow sufficient time to sediment the magnetic beads using a magnetic separator and consult the manufacturer's instructions for further information on the specific magnetic bead.

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