Deborah Liguori

PhD Student at UPNA

Deborah is from Brazil.
She holds a Master's Degree in Physics, and has a large experience teaching at diferents levels.
Moreover, she has a background in research due to a period of 3 years of undergraduate research in experimental Physics.

'I have a deep love for Science. My goal is to inspire curiosity and scientific literacy, fostering a society that values critical thinking'.

'Despite initially I didn't like Physics at all, during a captivating electricity lesson at school, I discovered the intriguing and marvellous world of Physics'.

Working under the supervision of Professor Alberto López Ortega, researcher of Physical Properties and Applications of Material Group at the Department of Sciences and the Institute of Advances Material an Mathematics (INAMAT).

Research

Preparation of innovative magnetic ferrites aiming the development of rare earth-free permanent magnets in a sustainable approach to energy production.

Research objective: to synthesize magnetic nanoparticles with the potential to substitute rare-earth-based permanent magnets in specific applications.

Abstract:

Permanent magnets are magnetic materials that store energy. When exposed to an external magnetic field, they exhibit **hysteric behavior** (Figure 1): Initially, with the application of a magnetic field, magnetization increases as field intensity rises until reaching a maximum, called saturation magnetization (Ms). However, upon field removal, the material maintains residual magnetization, known as remnant magnetization (M_R). To reset magnetization to zero, an opposing magnetic field is necessary, with intensity described as the coercive field (Hc).

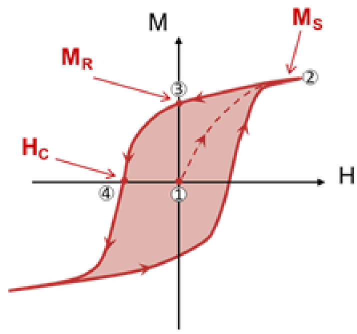

Figure 1.Hysteresis loop.
Magnetization (M) vs Applied Field (H)

Not all magnetic materials are suitable as permanent magnets. For a material to qualify as a permanent magnet, it must have **three key characteristics**: high Ms; high M_R; and resistance to demagnetization (large Hc). These traits result in a broad hysteresis loop, which is precisely the focus of this research. The figure of merit used to measure the strength of a permanent magnet is known as the **BHmax product**. This parameter can be represented graphically as the area of the largest rectangle that can be drawn in the second quadrant of the B-H loop (Figure 2a). Over the years, there has been a significant evolution in the field of permanent magnets (Figure 2b).

These magnets have diverse **applications in industries** like renewable energy, electronics, automotive, and medicine. Initially, for about 70 years in the 20th century, permanent magnets were mainly iron-based, including iron oxides and alloys. The 1970s marked a revolution by introducing rare-earth elements into magnet manufacturing, yielding much stronger devices. Consequently, interest in ferrite study diminished, and BHmax development for these materials stagnated.

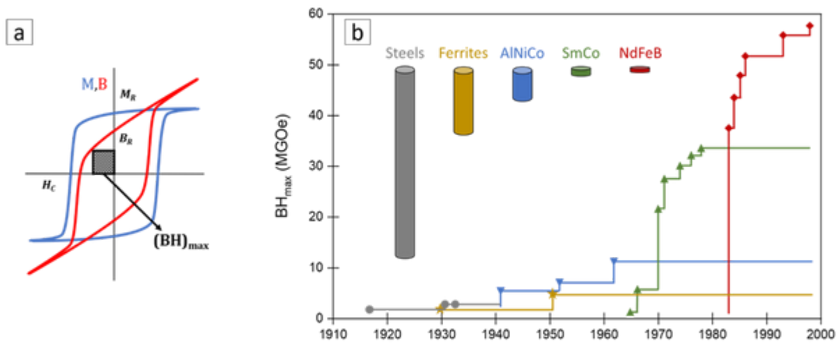

Figure 2a. Graphical representation of the figure of merit of permanent magnets.
Figure 2b. Evolution of the BHmax over the years.

Initially, there was little concern regarding the availability of raw materials required to produce these powerful magnets. However, in 2014, the European Commission released a new **list of critical raw materials**, which included rare-earth elements. Also, it is worth noting that China currently supplies 98% of the European Union's rare-earth element demand. Recognizing the **vulnerability** of relying heavily on a single source for such essential materials, the EU has acknowledged the crucial importance of rare-earth elements. The EU has highlighted the **high risk associated with their supply chain** and has proposed the development of **alternative solutions** to partially or completely substitute the current use of rare-earth-based permanent magnets. By reducing their import dependence, the EU aims to mitigate the potential risks and challenges associated with their supply.

As stated above, **ferrites** exhibit low BHmax products, and it is scientifically not realistic to think that we can develop ferrites with BHmax similar to those of rare-earth-based permanent magnets. However, if we can **increase the BHmax product by 10-20%**, some applications that nowadays require rare-earth-based permanent magnets could be covered with these **advanced ferrites**. Such advancements in ferrite technology would have a twofold **impact on the rare-earth market**. Firstly, it would reduce the European Union's dependence on importing these materials. Additionally, a decrease in demand for rare-earth elements could potentially lead to lower prices. Considering the advantages and limitations of ferrites that have been outlined, **this project is primarily focused on enhancing the energy product of ferrites**. By emphasizing this aspect, this research aims to explore avenues for improving the performance of ferrite magnets while recognizing their inherent limitations.