

MAGNETOPHORETIC SORTING OF FLUID CATALYTIC CRACKING PARTICLES

Miguel Solsona^{1*}, Anne-Eva Nieuwelink², Mathieu Odijk¹, Florian Meirer², Leon Abelmann^{2,3},
Wouter Olthuis¹, Bert M. Weckhuysen² and Albert van den Berg¹

¹MESA+ Institute for Nanotechnology, MIRA Institute for Biomedical Technology and Technical medicine, University of Twente, Drienerlolaan 5, 7522 NB Enschede, The Netherlands

²Inorganic Chemistry and Catalysis Group, Debye Institute for NanoMaterials Science, Faculty of Science, Utrecht University, 3584 CG Utrecht, The Netherlands

³KIST Europe, Campus E7, Saarbrücken, Germany

ABSTRACT

We demonstrate an on-chip particle activity sorter, focused on iron concentration and based on magnetophoresis. This device was used for fast sorting of stepwise homogeneously distributed [Fe]s. The preliminary results are very encouraging. We show that we can sort particles on magnetic moment, with a spread of a factor of four. XRF measurements confirm that the spread in magnetic moment is due to an increase in [Fe] concentration. This results fits well with particle trajectory simulations.

KEYWORDS: Magnetophoresis, catalysis, activity sorter

INTRODUCTION

This study aims at using magnetophoresis to develop an activity sorter focused on [Fe]. The main objective is to fabricate a device able to sort at stepwise homogeneously distributed [Fe]s. A better understanding of the catalyst's deactivation process is crucial to formulate better catalysts. Fluid catalytic cracking (FCC) particles have been used for more than 75 years and produce over 50% of gasoline and chemicals worldwide. Research on the deactivation process of such important catalysts is still ongoing since a small improvement can have enormous consequences for the environment. Besides, other porous catalyst used in biomass conversion or solar fuels can benefit from it.

FCC catalysts are heterogeneous porous particles with a diameter between 50–150 μm that deactivate with Fe and Ni coming from the feedstock, [1]. After being used, they are sorted by difference in density. Although in average, a higher density correlates with higher [Fe] and [Ni], which means less activity [2], it is known that some denser particles have less [Fe] and the other way around. In general, there is a need of a new kind of activity sorters just focused on the amount of Fe or Ni which are the real deactivators.

EXPERIMENTAL

In order to focus the particles inside the chip, a 2D flow focusing in a 3D printed chip was fabricated where the particles were focused at the first of the four outlets as well as at the same width. In order to demonstrate the performance of the 2D flow focusing a dye was introduced in the particle's inlet, Figure 2(b). VSM (vibrating sample magnetometer) and XRF (X-ray fluorescence), were used to study the magnetic and chemical properties of the sorted particles, respectively.

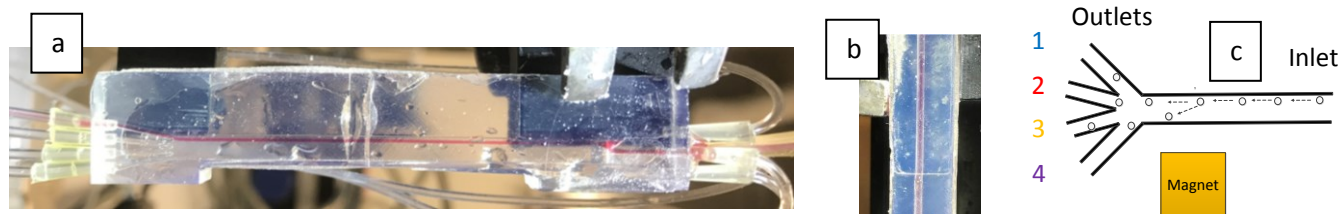


Figure 1: 3D printed chip with 2D flow focusing demonstration (a) front view, (b) side view and (c) sketch of magnet's position.

RESULTS AND DISCUSSION

A simulation based on the 2nd Newton's law and a 3D magnetic field distribution was developed, [3]. In order to know the performance of the simulation, purchased magnetic particles were introduced in a PDMS chip. In Figure

2 can be seen the results of the tracked and simulated trajectories showing a good agreement. The FCC particles were size presorted to a range between 85-100 μm , sorted with the magnetophoretic chip and their magnetic properties and chemical composition were studied. Figure 2b shows the magnetic moment of sorted particles coming from the 4 outlets. It can be seen that the saturation magnetization increases with a spread of a factor of 4.

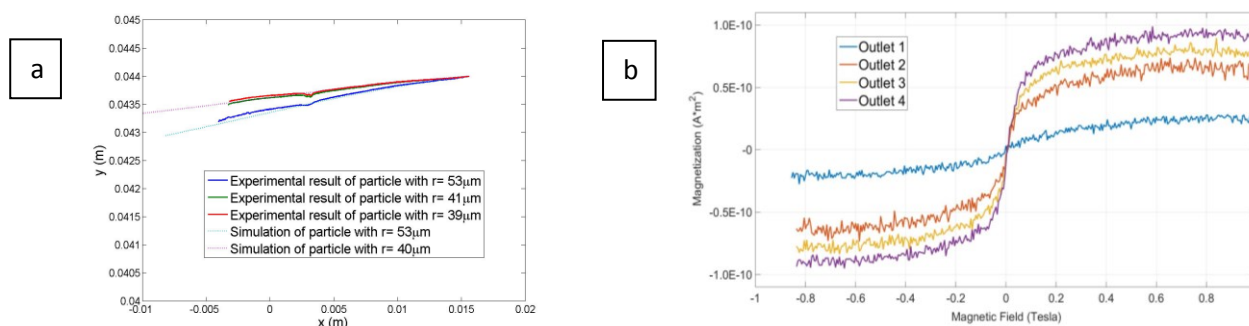


Figure 2: (a) Simulation and tracked trajectory of purchased magnetic particles and (b) magnetic moment experimental results of sorted FCC particles.

The magnetic moment plus the experimentally tracked FCC particle trajectories were used to demonstrate that the simulation works in a good agreement with the experimental results, Figure 3a. Figure 3b shows the [Fe] of the 4 outlets showing a good distribution of Fe.

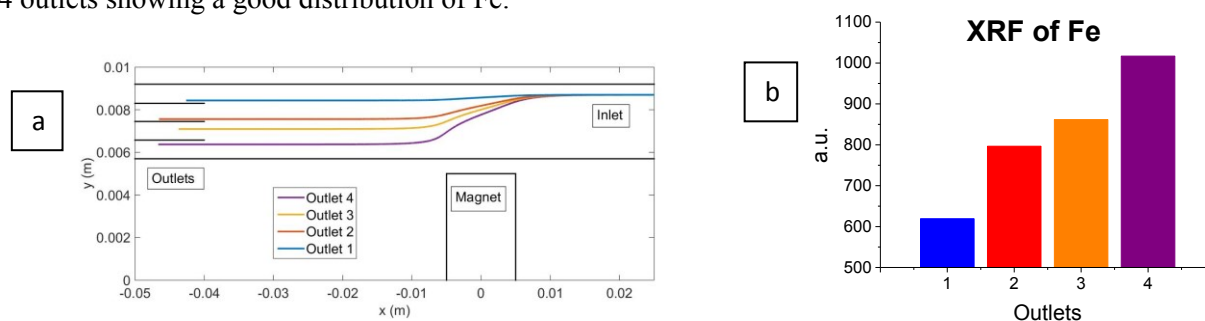


Figure 3: (a) Simulation of FCC particles and (b) Fe concentration experimental results of sorted FCC particle..

CONCLUSION

We developed a device able to sort particles on magnetic moment and correlate it with a good distribution on [Fe]. A simulation was used to design a 3D printed chip and experimental results indicate a good agreement. This new technique will provide new data and enhance our knowledge about FCC and other catalysts.

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REFERENCES

- [1] Vogt, E.T.C. and Weckhuysen, B.M., Chem. Soc. Rev. 44, p. 7342-7370, 2015.
- [2] F. Meirer, S. Kalirai, D. Morris, S. Soparawalla, Y. Liu, G. Mesu, J. Andrews, and B. M. Weckhuysen, Sci. Adv., 1, e1400199, 2015.
- [3] E.P. Furlani, J Appl. Phys 99,2: 024912.

CONTACT

* M.S: m.solsona@utwente.com