**3D-printed magnetically induced fluidized-bed reactor for electrochemical applications**

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**Highlights**

* Fully 3D-printed novel reaction system
* Solution of the contacting problem of a fluidized-bed electrode
* Improvement of electrochemical conversion by up to 100 percent with this system

**1. Introduction**

Electrochemical reactions are an interesting and versatile tool in modern bioengineering. On the one hand, they can be used for e.g. waste water treatment of pharmaceutical plants. On the other hand, electrochemical synthesis offers a way to transfer small organic building blocks originating from fermentations into higher value compounds.

Electrochemical processes proceed at the boundary between the electrode and the surrounding solution. In order to achieve high conversion rates, the ratio of electrode surface area to solution volume must therefore be maximized. Due to their high specific surface area, fluidized-bed electrodes are particularly suitable for this purpose. However, in practice they are rarely used because the controlled fluidization as well as the electrical contacting of these fluidized-beds are major challenges and so far only partially solved. One approach for better contacting of the conductive particle electrodes is the magnetically induced fluidized-bed reactor. Here, the fluidized bed is intended to be under the influence of a magnetic field and at the same time serve as an electrode for the electrochemical reaction.

**2. Methods**

To meet these challenges a scalable magnetically induced fluidized-bed reactor was designed and afterwards fabricated by 3D-printing. The fluidized-bed reactor consists of four elements and can be closed by means of two clamps. The reactor offers standard connectors, which allow e.g. the connection of analytical equipment like flow-through spectrometer, redox-electrode or pH-electrode. For the characterisation of the novel reactor design, suitable fluidized-bed particles and a model reaction for the electrochemical conversion were chosen. A composite material consisting of activated carbon and magnetite was used as fluidized-bed electrode with a particle size distribution between 100 µm and 300 µm. Before the electrochemical experiments, the percentage of the fluidized-bed expansion was measured at different flow rates. As model reaction, the reduction of potassium ferricyanide [K+]3[Fe(CN)63-] to potassium ferrocyanido [K+]4[Fe(CN)64-] was chosen. The electrochemical conversion in the fluidized-bed reactor was compared between the magnetically influenced system and the system without any magnetic influence.

**3. Results and discussion**

To improve the contact between the magnetic electrode particles, an external magnetic field was generated outside the reactor. **Figure 1 left** shows the expansion behavior of the fluidized bed electrode in relation to the different flow rates. Here the expansion of the fluidized bed electrode with and without magnetic field influence rises with increasing flow rate. Under the influence of a magnetic field, however, a reduced expansion behavior can be demonstrated, so that the assumption can be made that an improved electrode particle contact exists and an improved electrochemical conversion can be achieved. **Figure 1 right** shows the influence of the magnetic field on the electrochemical conversion. First, the achievable current can be increased by the addition of magnetic electrode particles only, meaning without the additional application of a magnetic field, simply because of the increased electrode area. However, if a magnetic field is applied an additional strong increase of the achievable current and therefore of the intensity of the corresponding electrochemical reaction can be observed. At an applied potential of -0.8V this increase achieves 100 percent from -2.2 A to -4.5 A.



**Figure 1. left**: Expansion in percent of the fluidized bed plotted against the flow rate in mL/min: Comparison with and without magnetic field at 10 mT; **right**: Current of the electrochemical model reaction: reduction of a 3 mM potassium ferricyanide solution in a magnetically induced fluidized-bed reactor

**4. Conclusions**

With the developed magnetically influenced electrochemical reaction system, the efficiency of fluidized particle electrodes can be strongly improved. This offers new potential applications of electrochemical reactions within solutions with suspended solids, which would quickly plug conventional particle or wire mesh electrodes.

**References**

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