DESIGN, REALIZATION AND PRELIMINARY EXPERIMENTAL EVALUATION OF A NOVEL MAGNETIC FILTER FOR UTILIZATION IN MAGNETICALLY-ASSISTED HAEMODIALYSIS

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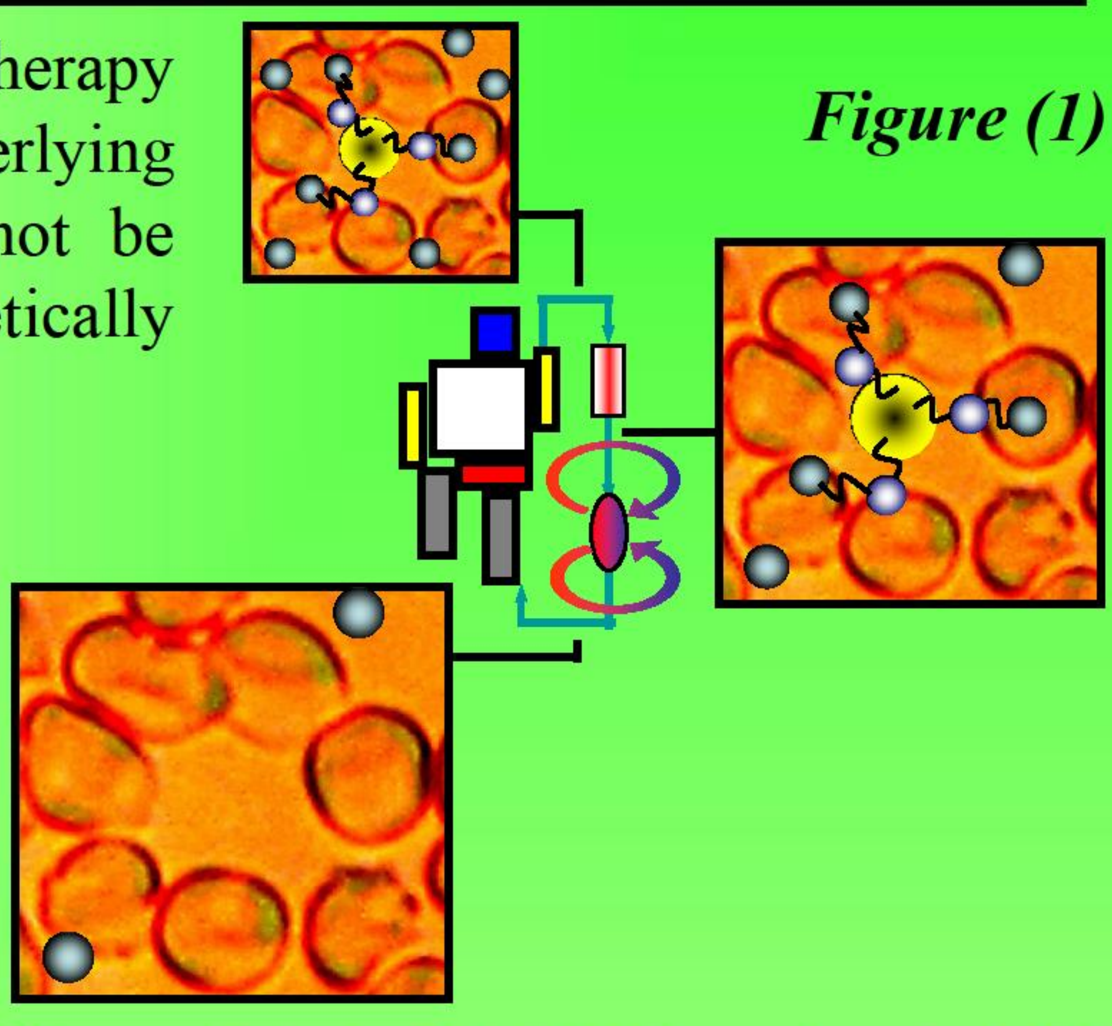
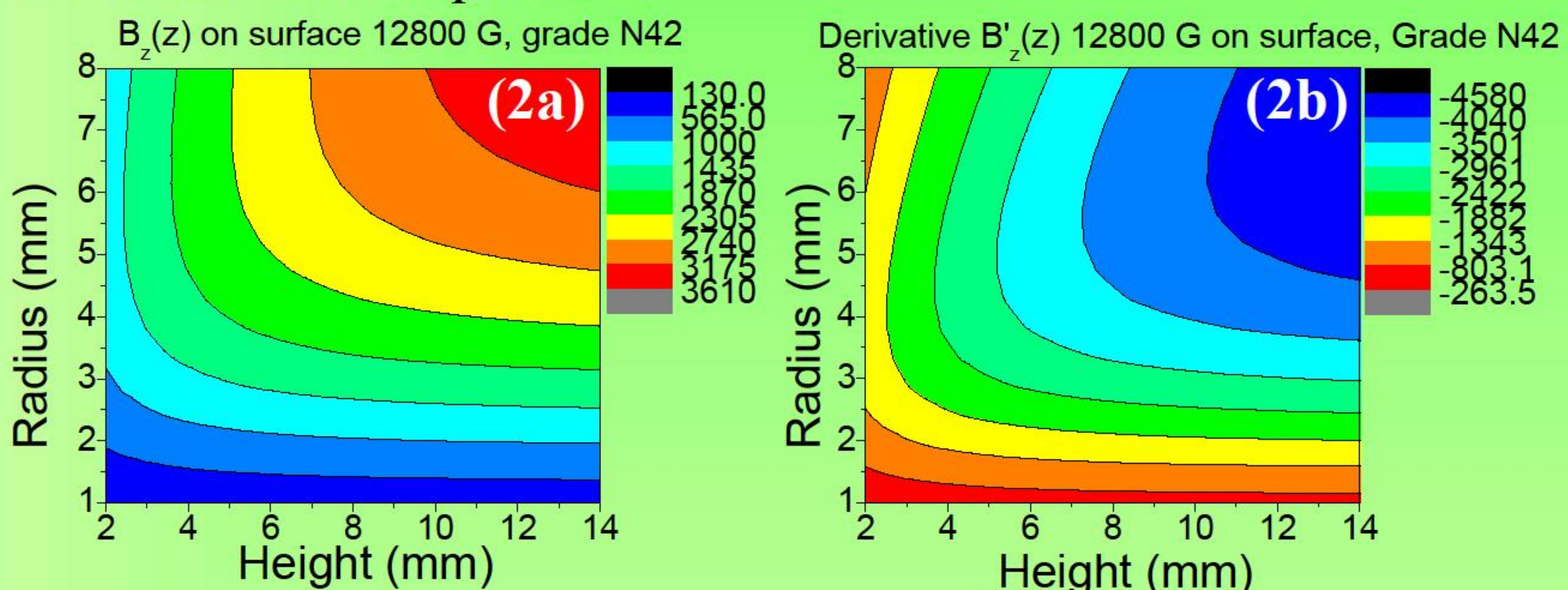
OBJECTIVES: Although Haemodialysis (HD) has become a mature replacement therapy it still has disadvantages such as slow toxin-removal kinetics (imposed by the underlying diffusion/convection processes) and non-selective action (undesired toxins cannot be distinguished from biomolecules that should be preserved). The so-called Magnetically Assisted HD (MAHD), Figure (1), introduces fast kinetics and selective action [1-6].

Figure (1)



Specifically, MAHD is based on core-shell conjugates (Cs) of two ingredients: a ferromagnetic particle (FP), the core that ensures the fast kinetics, and a biocompatible substance (BS) of high affinity for specific toxins, the shell that among others guarantees selectivity [1-6]. The Cs should be administered to the patient timely prior to the MAHD session, so that they will collect toxins while circulating in the cardiovascular. Ultimately the Cs are removed, together with the collected toxins, by a Magnetic Filter (MF) incorporated at the extracorporeal circulation line (ECL). Here we introduce a novel MF.

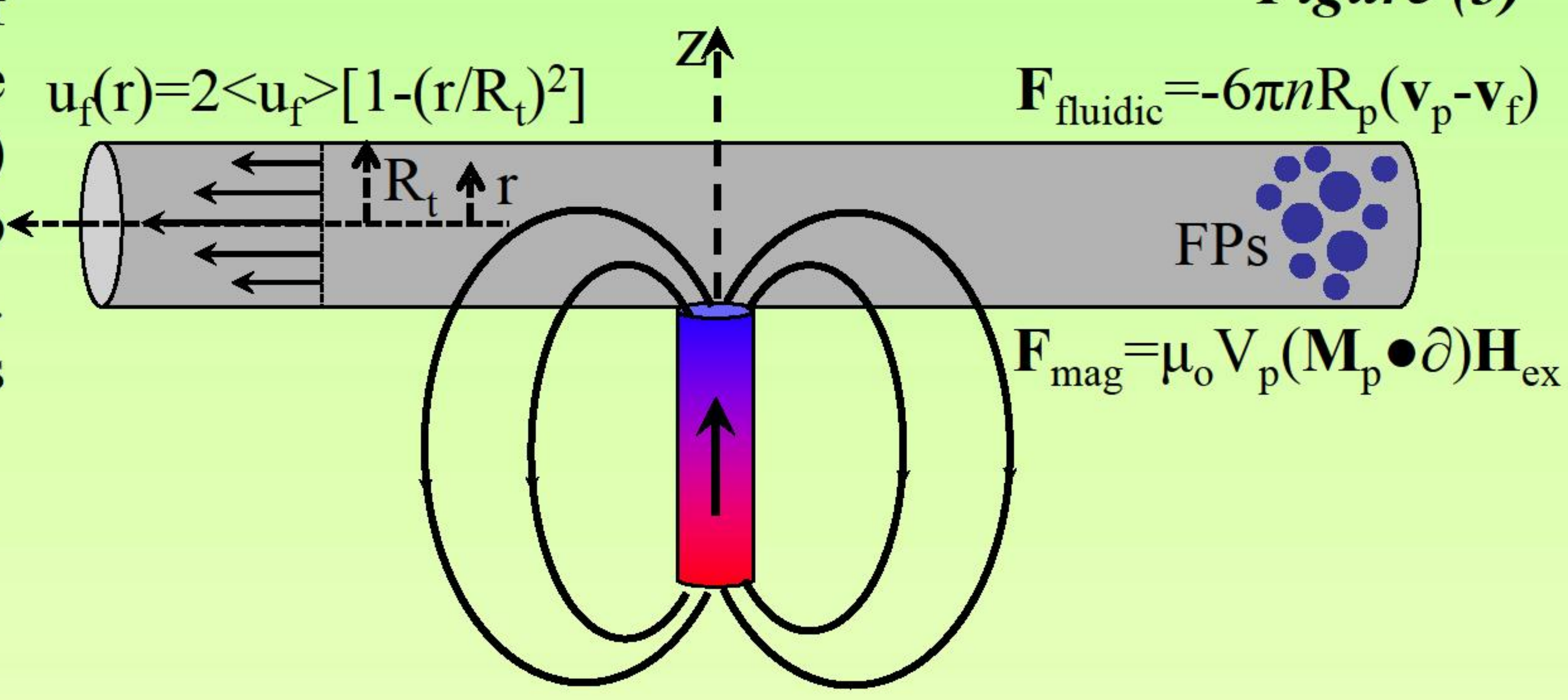
METHODS: Among others, the design of the MF was based on two main requirements: (a) production of intense magnetic force to achieve high efficiency on the removal of Cs and (b) absolute safety protecting the patient from the reentry of Cs into the cardiovascular system. Software packages (Finite Element Method Magnetics and Origin®) were used for the simulation of the magnetic field produced by the employed permanent magnets, Figures (2a)-(2b).

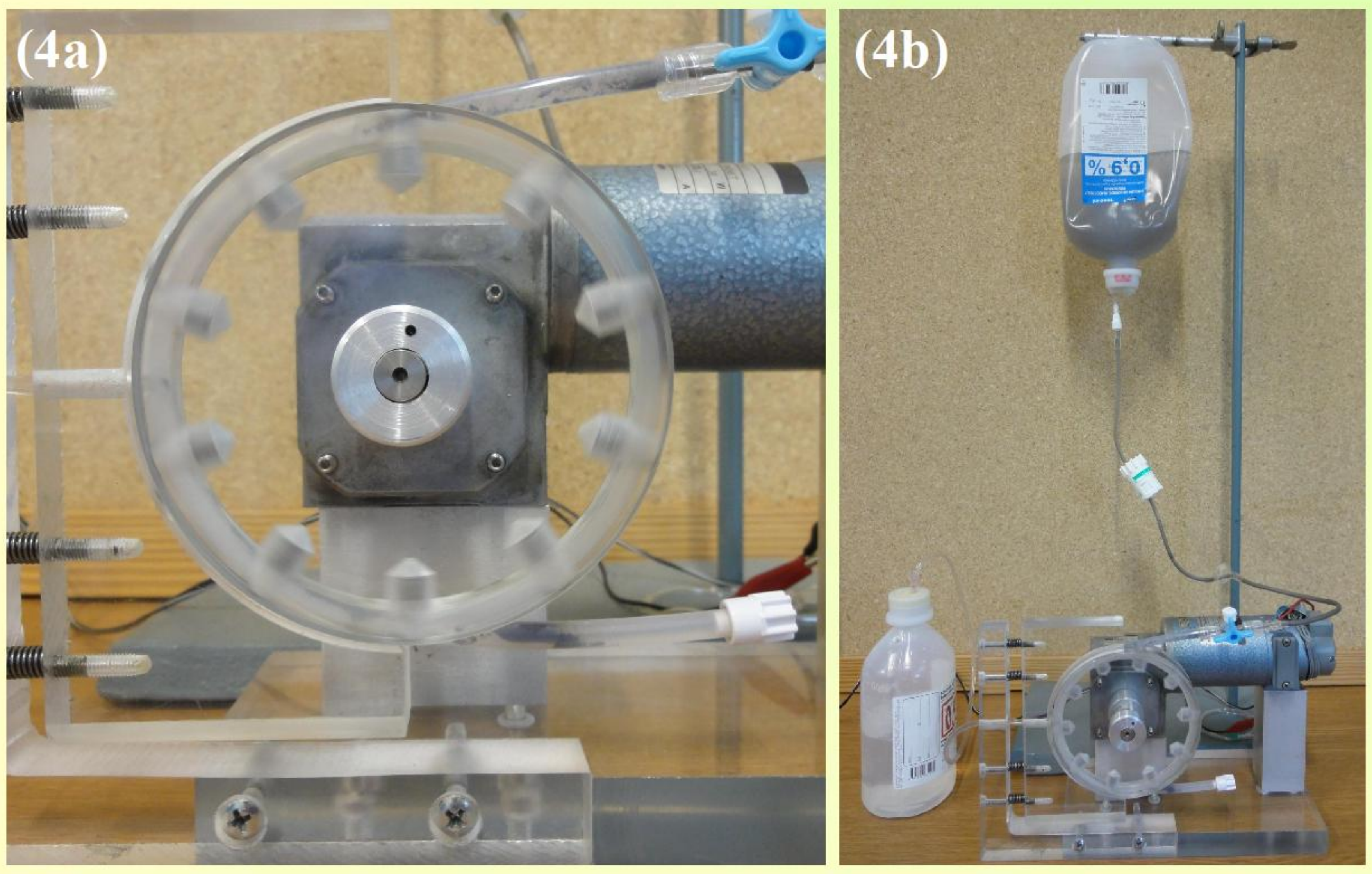


$$B(z)=\frac{B_r}{2}\left(\frac{L+z}{\sqrt{R^2+(L+z)^2}}-\frac{z}{\sqrt{R^2+z^2}}\right) \qquad B'(z)=\frac{B_r}{2}R^2\left(\frac{1}{\left[R^2+(L+z)^2\right]^{3/2}}-\frac{1}{\left[R^2+z^2\right]^{3/2}}\right)$$

RESULTS: Up to now [1,3,6] only ***static*** MF have been realized, Figure (3). Based on the safety issues and other requirements of MAHD [1-6] a prototype ***dynamic*** MF was designed and constructed, Figure (4a): a compact disc of diameter 13 cm with 10 permanent magnets (NdFeB, grade N42) of cylinder form (diameter 5 mm, height 5 mm) embedded uniformly along its periphery wherein a track also exists for the adjustment of the rigid tube of a modified ECL. The tube is adjusted in a way so that its outer surface is always in contact with the top surface of the magnets, Figure (4a).

Figure (3)





The disc rotates around its axis by electronically-controlled means with angular velocity that can be synchronized to the blood flow in the adjusted tube. This ensures the magnetic trapping of FPs flowing in the ECL that are subsequently guided to an isolation point, where farther processing can be performed, Figure (4a). The MF was experimentally tested with physiological saline as blood substitute in which FPs of iron (Fe) or iron oxide (Fe_3O_4) were dispersed, Figure (4b). The MF removed completely the FPs of Fe in a single round, while it needed a second round for the FPs of Fe_3O_4.

CONCLUSIONS: The MF introduced here can remove efficiently and safely FPs of Fe and Fe_3O_4 from an ECL. This opens interesting perspectives for its utilization in near-future *in vitro* experiments in the dialysis machine.

REFERENCES

*[1] D. Stamopoulos, D. Benaki, P. Bouziotis and P.N. Zirogiannis, Nanotechnology, **18**, 495102 (2007)*
*[2] D. Stamopoulos, E. Manios et al. Nanotechnology, **19**, 505101 (2008)*
*[3] D. Stamopoulos, P. Bouziotis, D. Benaki, C. Kotsovassilis and P.N. Zirogiannis, Nephrology Dialysis and Transplantation, **23**, 3234 (2008)*
*[4] D. Stamopoulos, V. Gogola, E. Manios, D. Niarchos, and M. Pissas, Current Nanoscience, **5**, 177 (2009).*
[5] D. Stamopoulos, et al. "Magnetically Assisted Hemodialysis: A New Strategy for Treatment of End Stage Renal Disease", Nova Science Publishers, (2009)
*[6] D. Stamopoulos, P. Bouziotis, D. Benaki, C. Kotsovassilis et al. Therapeutic Apheresis and Dialysis, **13**, 34 (2009)*

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