Blood Makes a Difference: Experimental Evaluation of Molecular Communication in Different Fluids – Supplementary Data Overview –

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OVERVIEW

In this document, we give an overview of the measurements we collected for the experimental evaluation of molecular communication (MC) in different fluids [1]. For our experiments, we use a testbed with superparamagnetic iron oxide nanoparticless (SPIONs) as signaling particles in 48 different configurations based on 4 changing channel characteristics. The background flow medium is water, blood substitute, or porcine blood. For each medium, we collect measurements for a channel length of 5, 10, 15, and 20 cm from the injection location to the middle of the sensor coil at a background flow velocity of 7.5 and 15 cm/s. Finally, we vary the injection geometry between an approximately uniform injection with two simultaneous injections at a 90° angle and approximating a point-source with an injection at a 0° angle into the channel via a cannula.

In the following figures, we present an overview of the collected measurements.¹ Figure 1 shows the sensor behavior for increasing blood flow after the background flow pump was turned on without SPIONs. All the following figures visualize the collected measurements sorted by background flow medium, injection types, and background flow velocities over increasing distances. In Figures 2, 3, 4, and 5, we visualize the collected measurements for the system impulse response (SIR) in blood. Figures 6, 7, 8, and 9 show the collected measurements for the SIR in blood substitute. The collected measurements for the SIR in water are included in Figures 10, 11, 12, and 13.

A full analysis of the different configurations and their results is available in our paper [1].



Fig. 1. Frequency shift in the sensor coil for the movement of blood without SPIONs at a background flow velocity of 15 cm/s. The iron content in the blood induces an offset in the resonance frequency of the sensor coil.

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REFERENCES

[1] L. Y. Debus, M. J. Wilhelm, H. Wolff, L. C. P. Wille, T. Rese, M. Lommel, J. Kirchner, and F. Dressler, "Blood Makes a Difference: Experimental Evaluation of Molecular Communication in Different Fluids," in 9th Workshop on Molecular Communications (WMC 2025), Catania, Italy, Apr. 2025.

¹The MATLAB scripts to produce the shown figures are available under https://github.com/tkn-tub/Molecular_Communication_in_Blood.



Fig. 2. SIR in blood for an injection at 90° and a background flow velocity of 15 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 3. SIR in blood for an injection at 90° and a background flow velocity of 7.5 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 4. SIR in blood for an injection at 0° and a background flow velocity of 15 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 5. SIR in blood for an injection at 0° and a background flow velocity of 7.5 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 6. SIR in blood substitute for an injection at 90° and a background flow velocity of 15 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 7. SIR in blood substitute for an injection at 90° and a background flow velocity of 7.5 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 8. SIR in blood substitute for an injection at 0° and a background flow velocity of 15 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 9. SIR in blood substitute for an injection at 0° and a background flow velocity of $7.5 \,\mathrm{cm/s}$ averaged over 8 consecutive pulses at a distance of $d = 5, 10, 15, \mathrm{and} 20 \,\mathrm{cm}$.



Fig. 10. SIR in water for an injection at 90° and a background flow velocity of 15 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.



Fig. 11. SIR in water for an injection at 90° and a background flow velocity of 7.5 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.

Fig. 12. SIR in water for an injection at 0° and a background flow velocity of 15 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.

Fig. 13. SIR in water for an injection at 0° and a background flow velocity of 7.5 cm/s averaged over 8 consecutive pulses at a distance of d = 5, 10, 15, and 20 cm.