Supplementary Figure 1: Oxygen partial pressure (pO2) as determined by RTDP fluorescence lifetime. (a) pO2 with respect to position for an aqueous phase entering a stream of deoxygenated oil (blue squares) and for a deoxygenated aqueous phase entering a stream of oil (red circles). The flow rate in both cases is 2 μL/min for the aqueous phase and 8 μL/min for the oil phase. (b) Same data as in (a) with respect to time. Zero position and time are defined to be at the center of the flow focuser. For deoxygenation the size of the droplets was 245 μm and the droplet speed was 5.8 mm/s. For oxygenation the size of the droplets was 259 μm and the droplet speed was 6.5 mm/s.

Supplementary Movie 1: Polarization microscopy image sequences of droplets flowing at a position 4 mm downstream from the flow focuser (about 12 seconds downstream) taken with a 10 X objective. The top and bottom image sequences are taken at the same location on the chip, 3 minutes apart. Top: Droplets flowing in oxygenated oil. Red blood cell appear as dark spots within droplets. Occasional irreversibly sickled cells appear as bright spots. Bottom: Droplets flowing in deoxygenated oil. Cells with HbS polymer fibers are birefringent and appear as bright spots in droplets. Fast moving cells appear as bright streaks. The image sequences are replayed at acquisition speed. The background was subtracted to remove the signal from microchip defects. The scale bar represents 100 μm.