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Quantifying the dynamic hydrophobicity of carbon black tattoo ink owing to ultrasound

Craig S. Carlson, Jean de Bruin Jordaan, Ken J. Nixon, and Michiel Postema

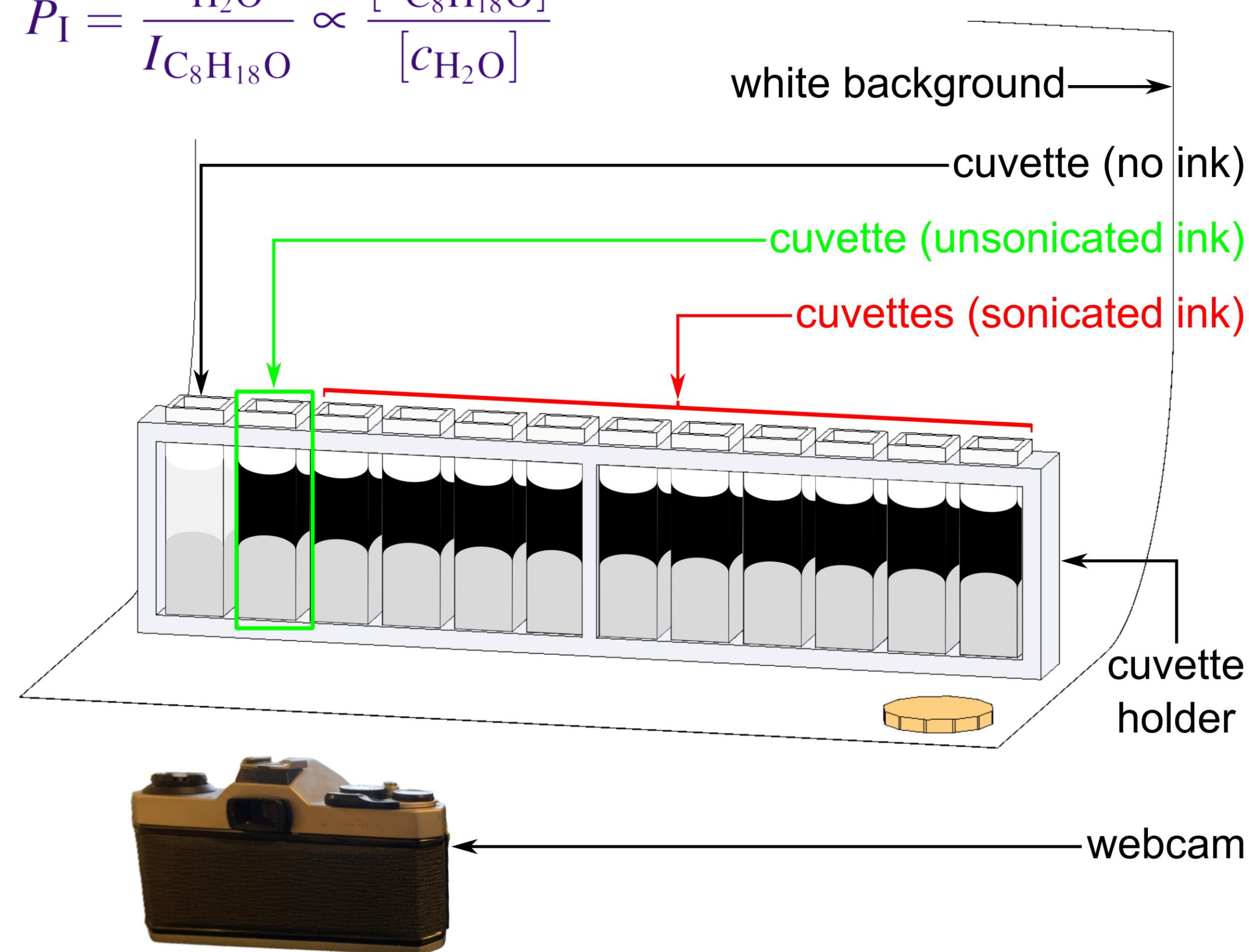
Despite growing academic interest of tattoos in society, the reason why tattoos are permanent has predominantly been studied from a biological perspective. In preliminary physics studies of tattoo ink, it has been presumed that the hydrophobicity of the pigment prevents absorption and therefore may be a contributing factor to a tattoo's permanence. According to these early studies, ultrasound might change the hydrophobicity of microparticles. The purpose of this study was to confirm the presence of hydrophobic components in carbon black tattoo ink and to relate sonication to such presence.

Materials and methods

- Cuvettes containing 1.5ml each of *n*-octanol and reverse osmosis distilled, degassed water.
- Zuper black pigment dispersion in a dilution of 0.25%.
- Custom-built unfocused single-element transducers.
- Ultrasound regime:
 - 5-minute exposure;
 - 1–10-MHz centre frequencies;
 - 1-kHz pulse-repetition frequency, 10% duty cycle;
 - 0–100-kPa peak-negative acoustic amplitudes.

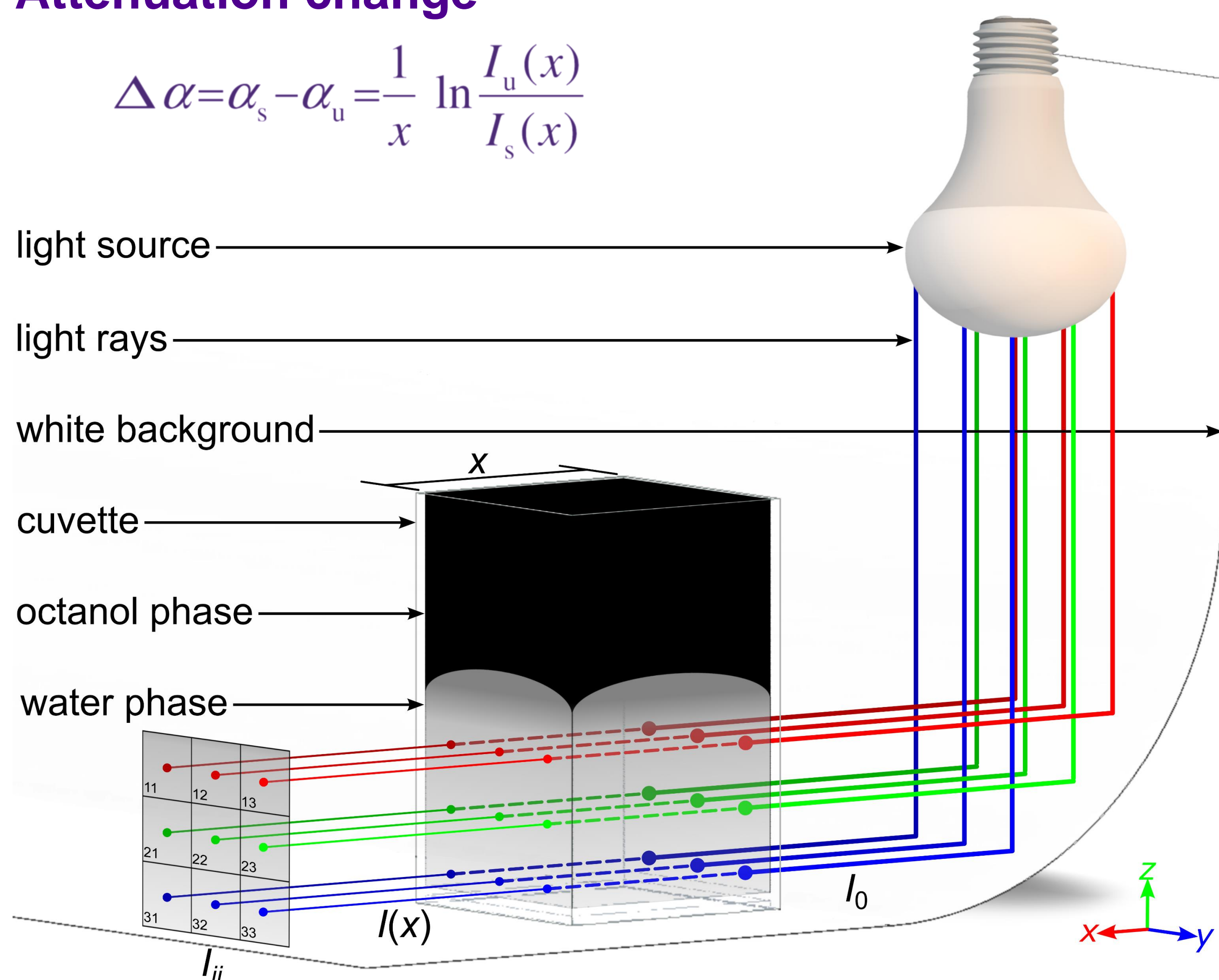
Light intensity measurements

$$P_I = \frac{I_{H_2O}}{I_{C_8H_{18}O}} \propto \frac{[C_8H_{18}O]}{[H_2O]}$$



Attenuation change

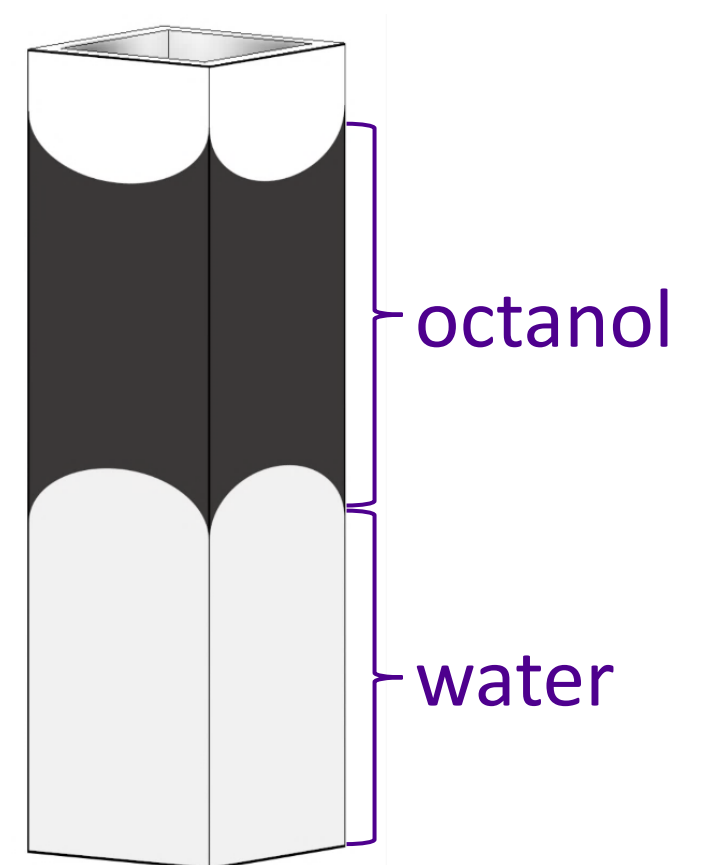
$$\Delta\alpha = \alpha_s - \alpha_u = \frac{1}{x} \ln \frac{I_u(x)}{I_s(x)}$$



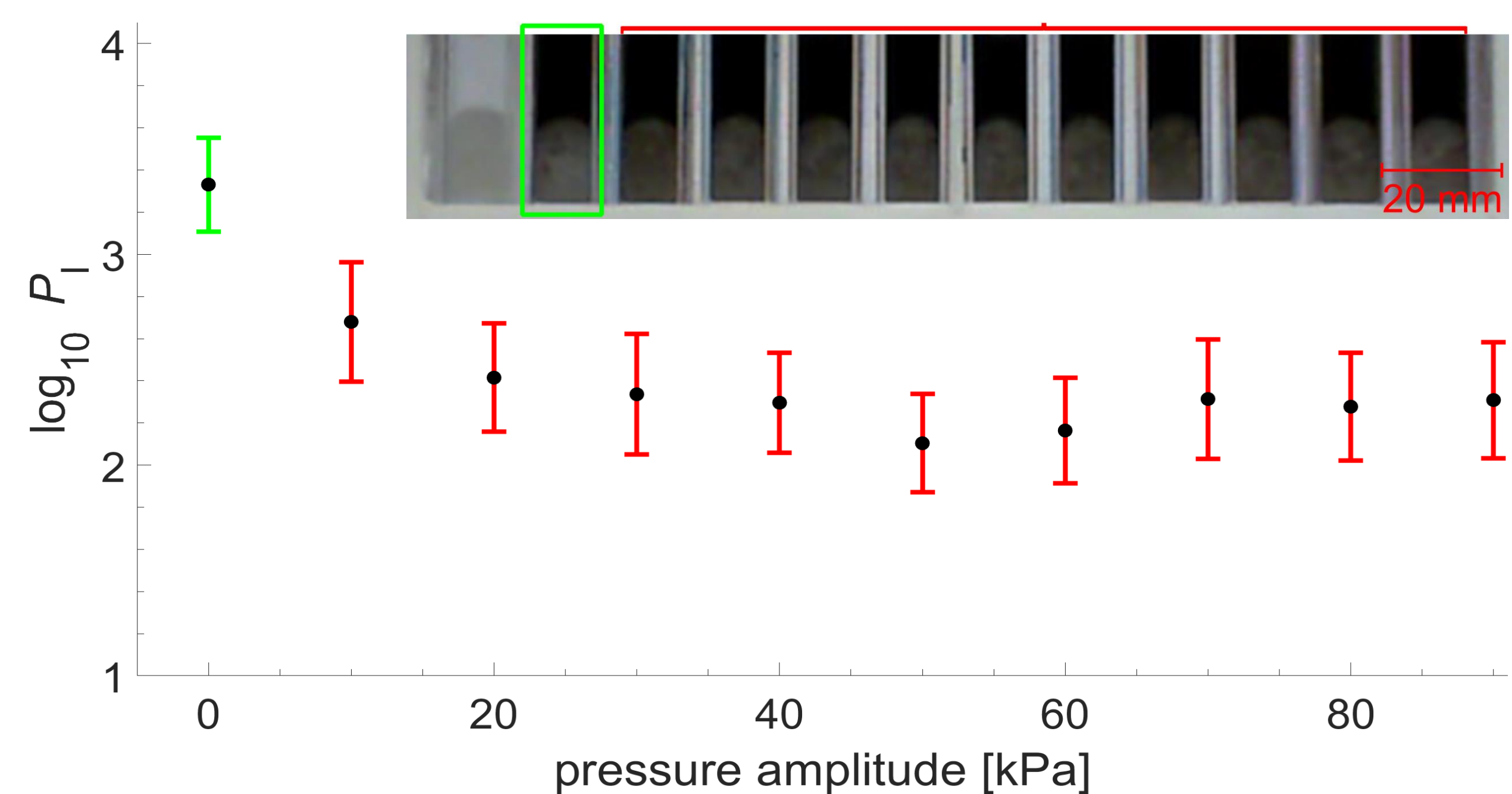
Quantifying hydrophobicity

- Hydrophobicity is quantified by the water-octanol partition coefficient.
- Determined using colourimetry.

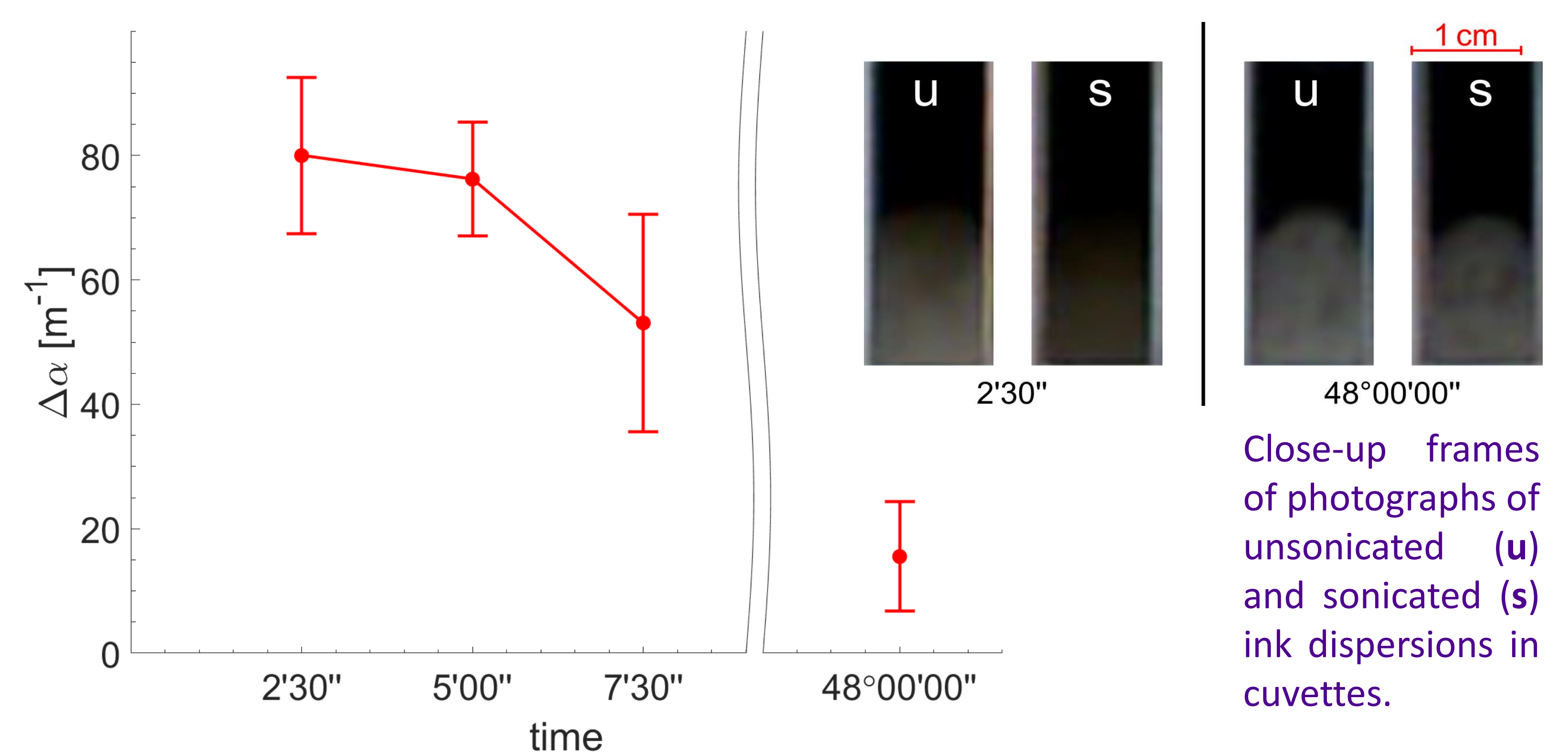
Hydrophilic	Hydrophobic
$P_I < 10^0$	$P_I > 10^0$ (extremely: $>10^4$)



Results



Light intensity partition coefficients of carbon black tattoo ink as a function of pre-applied ultrasound pressure amplitude. Coefficients have been represented on a logarithmic scale. Cropped frontal photograph of a representative experiment inset, showing a cuvette with no ink, a cuvette with unsonicated ink (green), and ten cuvettes with sonicated ink (red) at different pressure amplitudes.



Mean differences in absorption coefficients between unsonicated and sonicated dispersions $\Delta\alpha$, as a function of time.

Conclusions

- Carbon black tattoo ink was found to be very hydrophobic.
- Sonication made the dispersion less hydrophobic, with some dynamic changes observed.
- Influencing the hydrophobicity of tattoo ink might change the permanence of a tattoo.

Author statement

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Conflict of interest: Authors state no conflict of interest.

Ethical approval: Ethical clearance was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg (clearance certificate no. M190808 MED19-07-006).

