Electronic Supplementary Material (ESI) for Lab on a Chip.

Electronic Supplementary Information

Neonatal Jaundice Diagnostics on a Chip: 3D Microfluidic Tape-paper-based Sensing Device for Blood Total Bilirubin Measurement

Weirui Tan[1], *Liyuan Zhang*[1,2,*], *James C. G. Doery*[3,4], *Wei Shen*[1,*]

1. Department of Chemical Engineering, Monash University, Wellington Road, Clayton, VIC 3800, Australia
2. National Local Joint Engineering Laboratory for Advanced Textile Processing and Clean Production, Science and Technology Institute, Wuhan Textile University, Wuhan 430200, China
3. Monash Pathology, Monash Health, Clayton Road, VIC 3168, Australia
4. Department of Medicine, Monash University, Wellington Road, Clayton, VIC 3800, Australia

* Corresponding authors: wei.shen@monash.edu, liyuan.zhang@monash.edu

The diazo reaction mechanism of total bilirubin (unconjugated bilirubin (UCB) and conjugated bilirubin (CB))

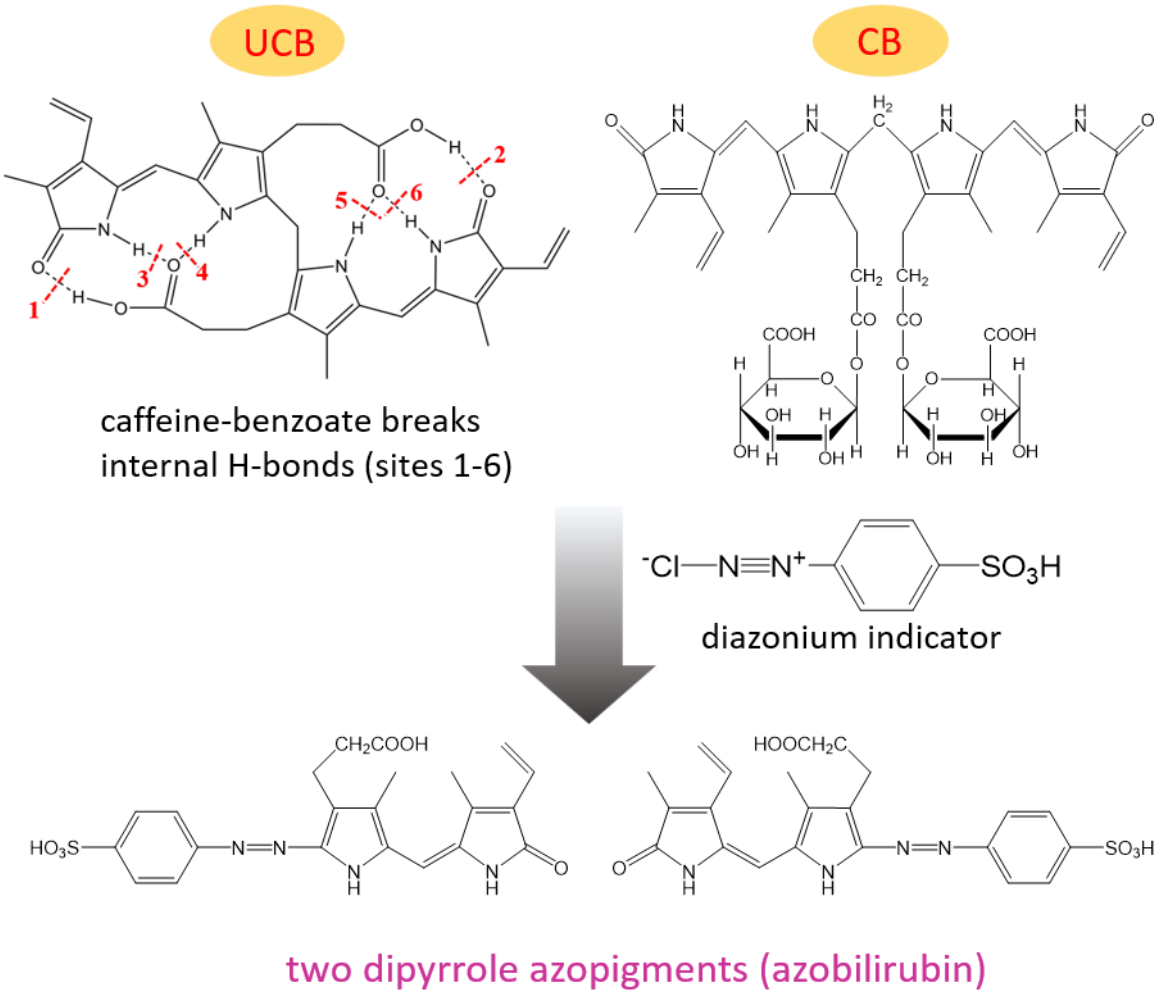

Fig. S1 The reaction principle of diazotization of unconjugated bilirubin (UCB) and conjugated bilirubin (CB) to generate two purple dipyrrole azopigments (azobilirubin products).

Modified Lucas-Washburn equation to describe the aqueous liquid transport in swellable cellulose fibre networks

$$L_{lf} = \sqrt{\frac{\gamma R_0 \cos\theta}{2\mu}} \sqrt{\frac{3R_0^2 t + a^2 t^3 - 3aR_0 t^2}{3R_0^2}} \quad \text{(S1)}$$

where L_{lf} is the length of the advancing liquid-front within the porous medium (mm); γ is the liquid surface tension, θ is the contact angle, μ is the liquid viscosity, t is time, a is the pore radius reduction rate (a constant ratio related to the rate of decreasing pore radius, the reciprocal of time with the unit of 1/s), R_0 is the initial pore radius. In this modified equation, the effect of gravity is negligible. The modified Lucas-Washburn equation works when the wicking time is not greater than the maximum-permitted swelling time for individual fibers.[1]

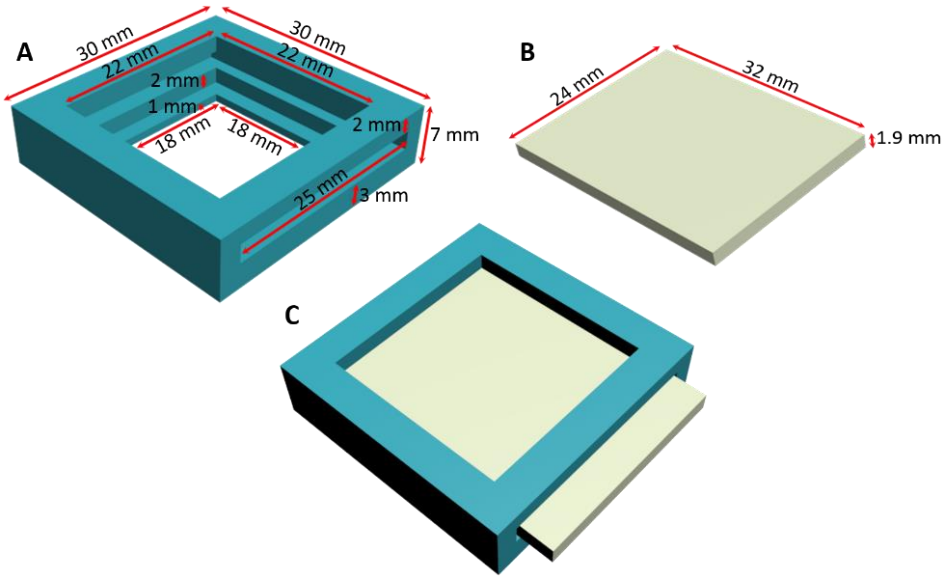

Fig. S2 The schematic demonstration of the 3D-printed mould: (A) the accommodation mould; (B) the sliding block; (C) the assembled mould.

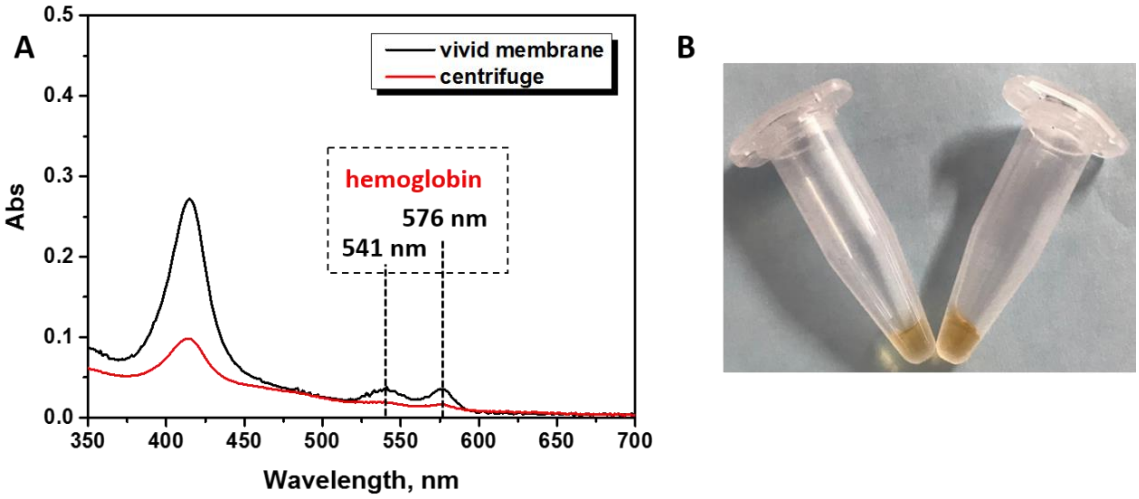

Fig. S3 Comparison of the hemoglysis in the plasma extracted by the vivid membrane and centrifuge. (A) The UV-vis absorbance spectra of plasma extracted by the vivid membrane and the centrifugation method. (B) Photos of plasma gained by centrifuge (left) and the vivid membrane (right).

Table S1. Consensus-based bilirubin thresholds for the management of babies of 38 weeks or more gestational age with high concentration of bilirubin.[2]

Age (hours)	Bilirubin measurement (micromol/litre)			
0			> 100	> 100
6	> 100	> 112	> 125	> 150
12	> 100	> 125	> 150	> 200
18	> 100	> 137	> 175	> 250
24	> 100	> 150	> 200	> 300
30	> 112	> 162	> 212	> 350
36	> 125	> 175	> 225	> 400
42	> 137	> 187	> 237	> 450
48	> 150	> 200	> 250	> 450
54	> 162	> 212	> 262	> 450
60	> 175	> 225	> 275	> 450
66	> 187	> 237	> 287	> 450
72	> 200	> 250	> 300	> 450
78		> 262	> 312	> 450
84		> 275	> 325	> 450
90		> 287	> 337	> 450
96+		> 300	> 350	> 450
Action	↓ Repeat bilirubin measurement in 6–12 hours	↓ Consider phototherapy and repeat bilirubin measurement in 6 hours	↓ Start phototherapy	↓ Perform an exchange transfusion unless the bilirubin level falls below threshold while the treatment is being prepared

Table S2. Cost estimation for development of one tape-paper-based sensing device, which should be less than AUD 0.6.

Item	Market price per quantity	Quantity per PAD	Cost per device, A$
bilirubin assay kit	A$ 430/1260 tests	1 test (10 µL)	0.341
filter paper	A$ 45/(63.585 cm^2 × 100 sheets)	1.5 × 1.5 cm^2 × 2 pieces	0.032
plasma separation membrane	A$ 56/(619.5 cm^2 × 10 sheets)	2 × 2 cm^2	0.036
3M Scotch magic tape	A$ 5.6/(19 mm × 33 m)	19 mm × 0.07 m	0.012
caffeine	A$ 47.5/100g	0.85 mg	0.0004
sodium benzoate	A$ 72.5/250g	0.85 mg	0.0002
wax printing			0.0001 estimated
3D-printed resin mould			< 0.1 estimated
Total			0.5217 **~ 0.6**

REFERENCES

1 D. R. Schuchard and J. C. Berg, *Wood and Fiber Science*, 1991, **23**, 342-357.

2 The neonatal jaundice clinical guideline can be viewed or downloaded through the link: https://www.nice.org.uk/guidance/cg98/evidence/full-guideline-245411821.