Supplementary Materials

S1. UV/Vis absorption spectra

(i) CO_2 indicator for aquaria

Most CO_2 drop-checkers use a CO_2 indicator solution that employs the pH indicator dye bromothymol blue, BTB, dissolved in an aqueous sodium bicarbonate solution. In order to validate that the dye used in the commercial Fluval CO_2 indicator for aquaria was, in fact, BTB, the UV/Vis absorption spectrum of the Fluval indicator solution was compared with that of the lab-based drop check indicator solution, which contained BTB in an aqueous 1.43 mM $NaHCO_3$ solution. In this work, a 3 ml sample of the indicator solution was placed in a 1 cm cuvette and its UV/Vis spectrum recorded and the results of this work are illustrated in Figure S1. A brief examination of the two spectra illustrated in Figure S1 showed that both had the same value for the absorption maximum, $\lambda_{max}(D^-)$ = 617 nm. Other work showed that they also had the same value for λ_{max} for the protonated form of the pH dye, λ_{max}(HD), i.e. 431 nm. The strong similarity in the UV/Vis absorption spectra of the Fluval and lab-based drop check indicator solutions is taken as evidence that they both

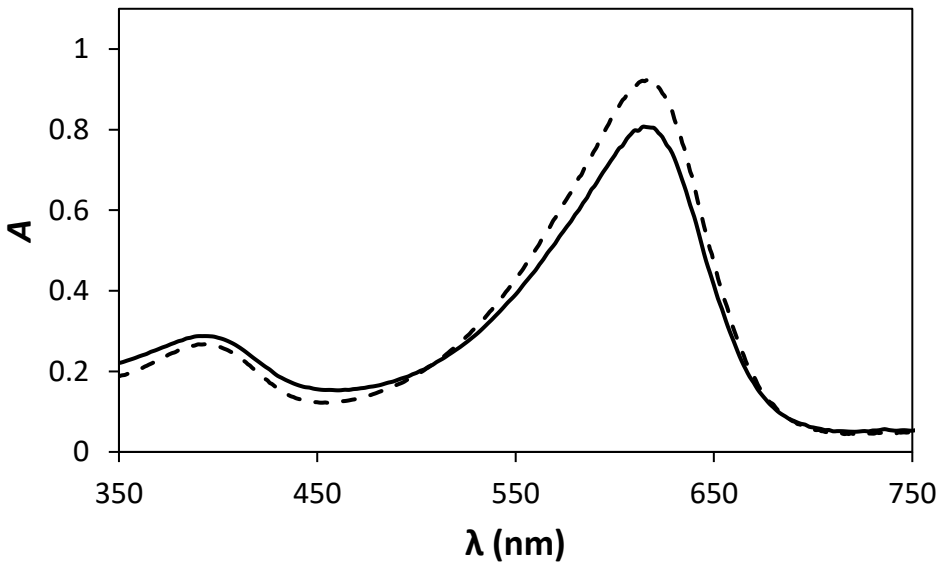


Figure S1. UV/vis spectra of the lab-based drop check indicator solution (solid line), comprising 2.71 x 10^{-5} M BTB in a 1.43 mM $NaHCO_3$ aqueous solution and that of athe Fluval indicator solution (broken line), in which [BTB] = ca. 2.96 x 10^{-5} M BTB.

(ii) CO_2 indicator for capnography

Most commercial CO_2 indicators used for capnography employ an ink that comprises a pH indicator and base dissolved in a non-volatile, hygroscopic liquid, such as glycerol, that is absorbed onto a filter paper-type substrate. In order to identify what pH-Sensitive dye was used in Easy Cap indicator, the dye was extracted into an aqueous solution by soaking the indicator in a small amount, 14 mL, of water for 30 min, at which point the indicator had completely lost its colour and the water was coloured. The UV/Vis absorption spectrum of the dye-containing aqueous solution, was then recorded as in (i). In order to effect a useful comparison with that of the cresol red, CR, used to make the lab-based capnography indicator, ca. 1 ml of ink used to make the indicator was diluted with 31 ml water and its absorption spectrum then run. to give a similar absorbance to that of the Nellcor™ dye in water. The two UV/Vis absorption spectra so obtained are illustrated in Figure S2, a brief inspection of which reveals that both shared the same $\lambda_{max}(D^-)$ value of 573 nm, and other works showed that their $\lambda_{max}(HD)$ values were also the same, i.e. 433 nm. The strong similarity in the UV/Vis absorption spectra of the aqueous solutions of the dye used to make the Easy Cap and lab-based capnography drop is taken as evidence that they both employ the same pH sensitive dye, namely cresol red, CR.

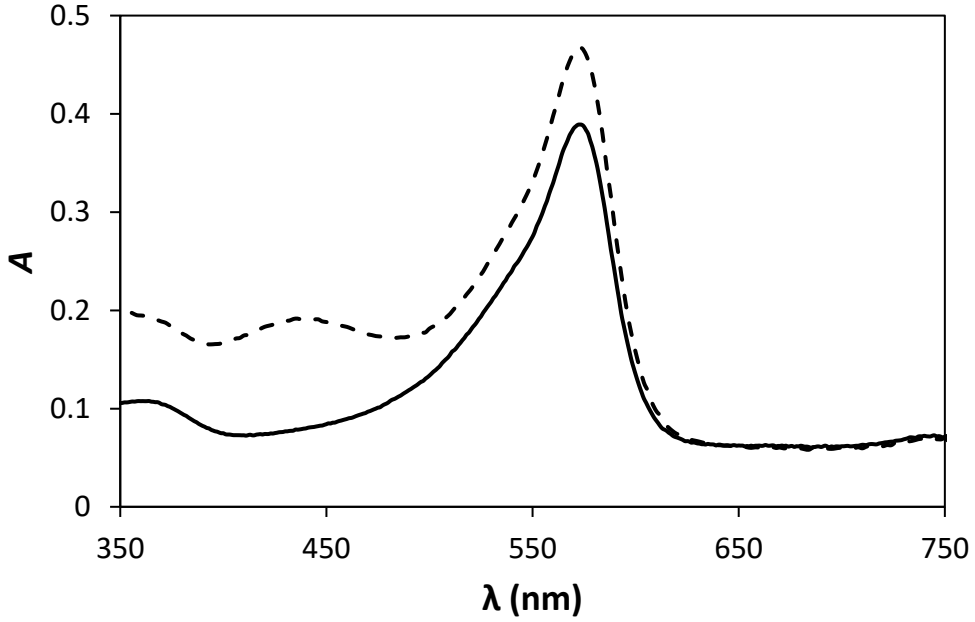


Figure S2. UV/vis spectra of (solid line) an aqueous solution of the cresol red (CR) dye used to make the lab-based capnography indicator and that of the dye in aqueous solution used to make the Easy cap indicator.

Table S1. Wavelengths of the absorption maxima for the deprotonated and protonated forms of the BTB and CR dyes in aqueous solution

Dye	**Abbreviation**	**$\lambda_{max}(D^-)$ (nm)**	**$\lambda_{max}(DH)$ (nm)**
Bromothymol blue	BTB	618	430
Cresol red	CR	573	432

S2. Photographing the capnography indicators

The gas cell set up used in the characterisation of the capnography and plastic film CO_2 indicators is shown in Figure S3. Briefly, this set up involved the indicator being placed in a gas cell with a glass detachable face, through which different compositions of CO_2/Ar gas were purged. Photographs of the indicator at each CO_2 level under test were taken through the glass top face of the cell using a Canon 7D camera with 18-55mm lens.

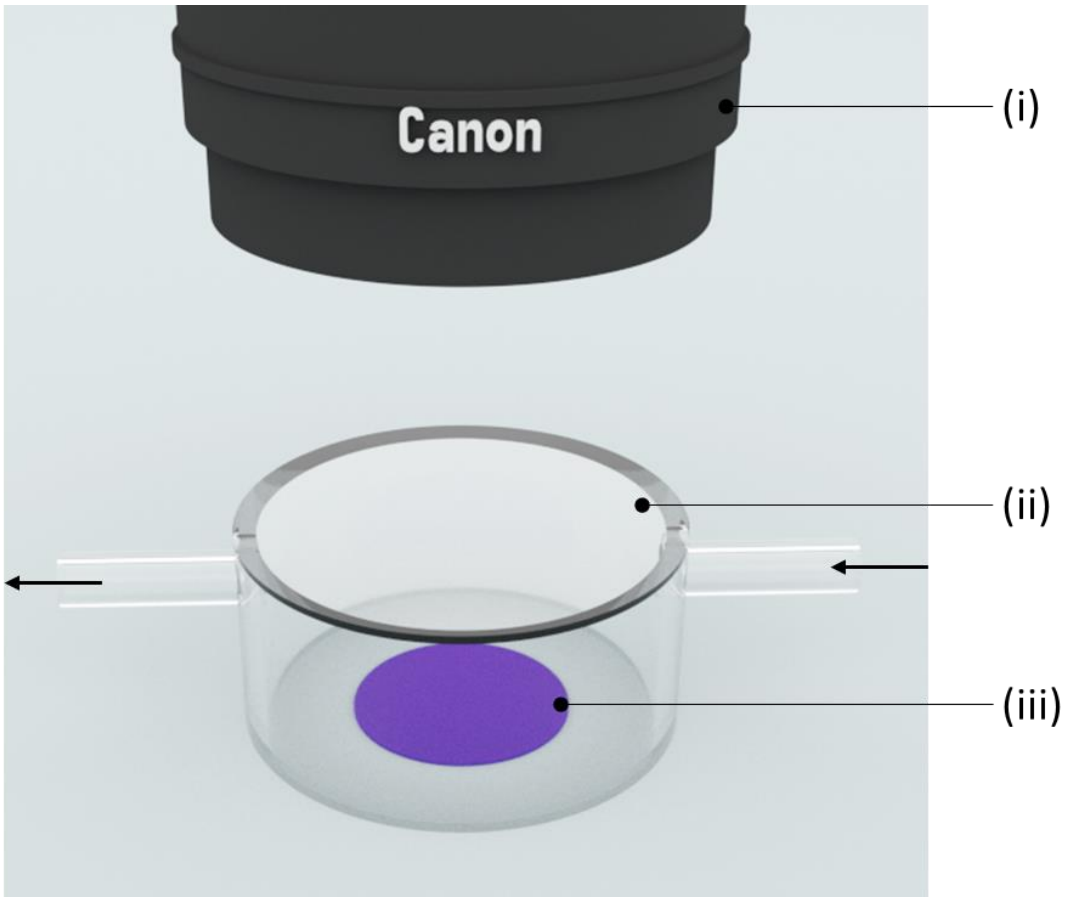
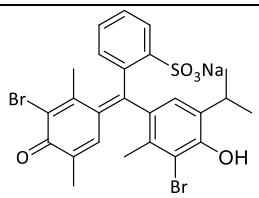
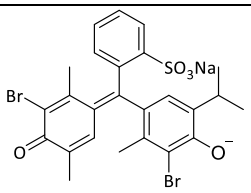
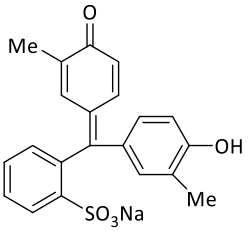
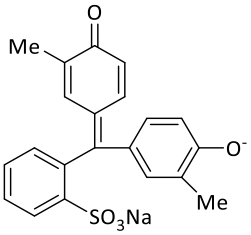


Figure S3. Schematic illustration of the set up used to record the digital images of the indicator film under test when exposed to different, known levels of CO_2 in CO_2/Ar gas stream, generated using a gas blender. The key components of the system were, (i) digital camera, (ii) glass gas cell with detachable face and (iii) indicator film under test.

S3 Structures and pK_a values of BTB and CR

The dyes used in the indicators reported in this work, bromothymol blue (BTB) and cresol red (CR), belong to the sulfonephthalein dye class and the structures of their protonated and deprotonated forms, as well as their pK_a values are given below in Table S1.

Table S2. Structures and pK_as of BTB and CR

Dye	**Abbreviation**	**Structure of HD***	**Structure of D^-***	**pKa**
Bromothymol blue	BTB	 (yellow)	 (blue)	7.3
Cresol red	CR	 (yellow)	 (purple)	8.2

*Structure of sodium salt shown.

S4 Measured RGB(*red*), and calculated A' and *R* data for the drop check indicators

Table S3. Measured RGB(red), and calculated A' and R data as a function of % CO_2 for the lab based and commercial BTB-based aquaria indicators.

Indicator	**% CO_2**	**RGB(red)**	***A'***	***R****
Lab-based	0.0	83.37	1.14	0
	0.04	92.32	1.04	0.12
	0.1	98.60	0.96	0.24
	0.2	112.74	0.83	0.49
	0.5	133.19	0.66	1.09
	1.0	155.88	0.50	2.26
	2.0	173.41	0.40	4.05
	3.0	185.84	0.33	7.15
	4.0	190.29	0.31	9.31
	5.0	194.79	0.30	12.68
	100	208.76	0.22	-
Commercial	0.0	57.19	1.39	0
	0.04	60.04	1.34	0.03
	0.1	67.30	1.25	0.12
	0.2	84.91	1.04	0.37
	0.5	115.04	0.77	0.95
	1.0	132.22	0.64	1.44
	2.0	184.11	0.32	5.28
	3.0	193.39	0.27	7.21
	4.0	201.96	0.23	10.29
	5.0	202.87	0.22	10.75
	100	226.55	0.12	-

*Lab based indicator assumes A'_{∞} = 0.22 and A'_0=1.14. Commercial indicator assumes A'_{∞} = 0.12 and A'_0=1.39

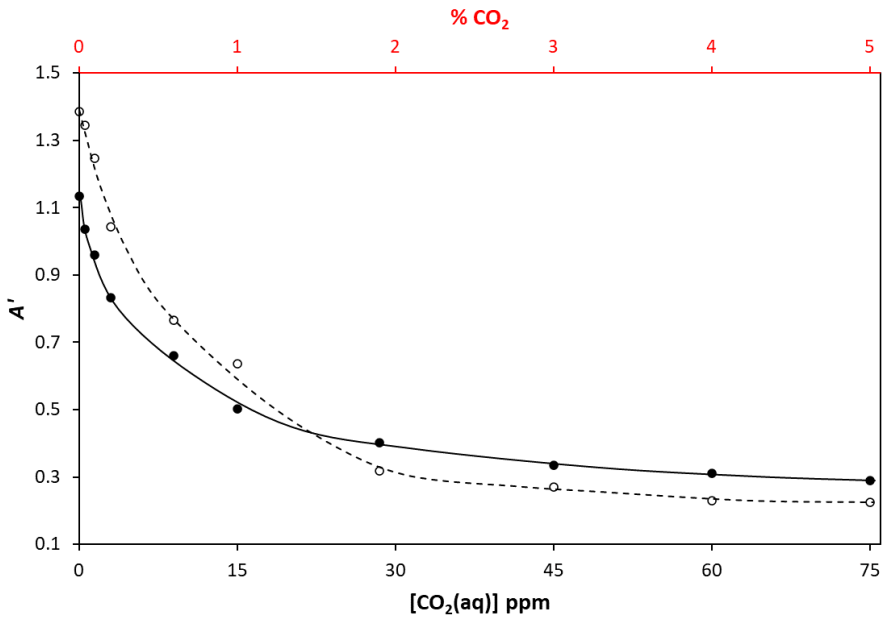


Figure S4. Plots of *A'* vs [CO_2(aq)] (in ppm) and % CO_2 for (black circles, solid line) the lab-based and (open circles, broken line) the commercial Fluval BTB-based CO_2 indicators for aquaria. Data from Table S3.

S5 *A* versus *A'* validation and table of measured RGB(*red*), and calculated A' and *R* data for the capnography indicators

Confirmation that *A* is proportional *A'* when using CR was achieved using an aqueous solution of the dye in otherwise the same degassing experiment as employed for BTB, see Figure 1, the results of which are illustrated below in Figure S5.

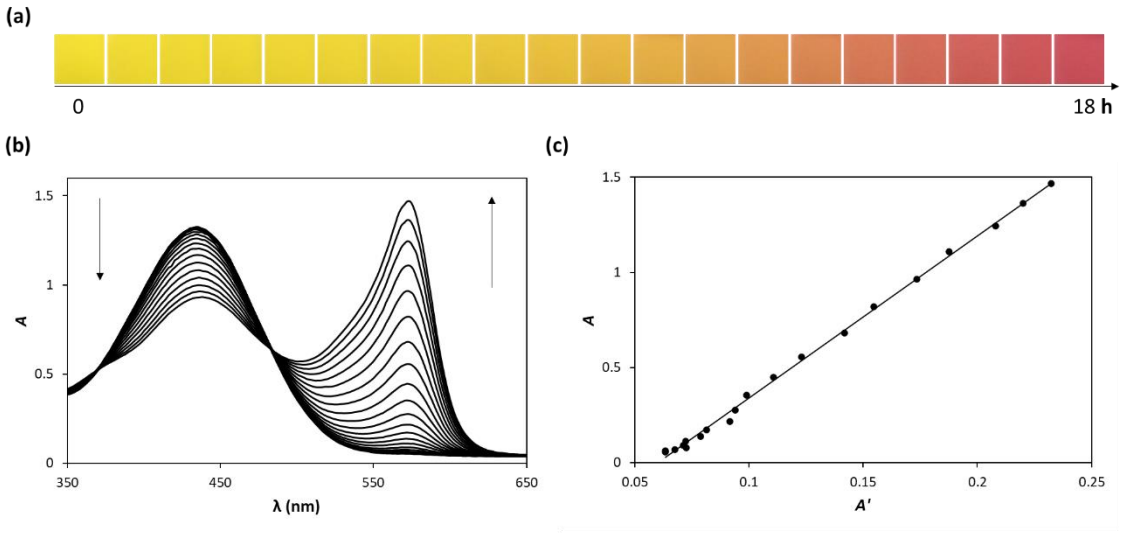


Figure S5. Regularly recorded, (**a**) digital photographic images and (**b**) UV/Vis absorption spectra of a $NaHCO_3$ aqueous solution (1.43 mM) containing CR, initially saturated with 100% CO_2 for 10 minutes and then allowed to lose the dissolved CO_2 to ambient air over time and (**c**) subsequent plot of *A* vs *A'* for the same solution, with values of *A* and *A'* determined from the UV/Vis spectrum in (**b**) and the photographic images in (**a**), respectively.

Table S4. Measured RGB(red), and calculated A' and R data as a function of % CO_2 for the lab based and commercial CR-based capnography indicators.

Indicator	**% CO_2**	**RGB(red)**	***A'***	***R****
Lab-based	0.0	209.27	0.19	0
	0.04	212.65	0.18	0.12
	1.0	225.01	0.12	0.91
	2.0	230.29	0.10	1.70
	3.0	233.50	0.09	2.58
	4.0	235.25	0.08	3.35
	5.0	237.09	0.07	4.61
	100	243.57	0.05	-
Commercial	0.0	213.42	0.17	0
	0.04	216.49	0.16	0.09
	1.0	231.05	0.10	0.92
	2.0	238.06	0.07	1.94
	3.0	241.24	0.05	2.85
	4.0	242.98	0.05	3.62
	5.0	244.66	0.04	4.72
	100	251.798	0.01	-

*Lab based indicator assumes A'_{∞} = 0.05 and A'_0=0.19. Commercial indicator assumes A'_{∞} = 0.01 and A'_0= 0.17.

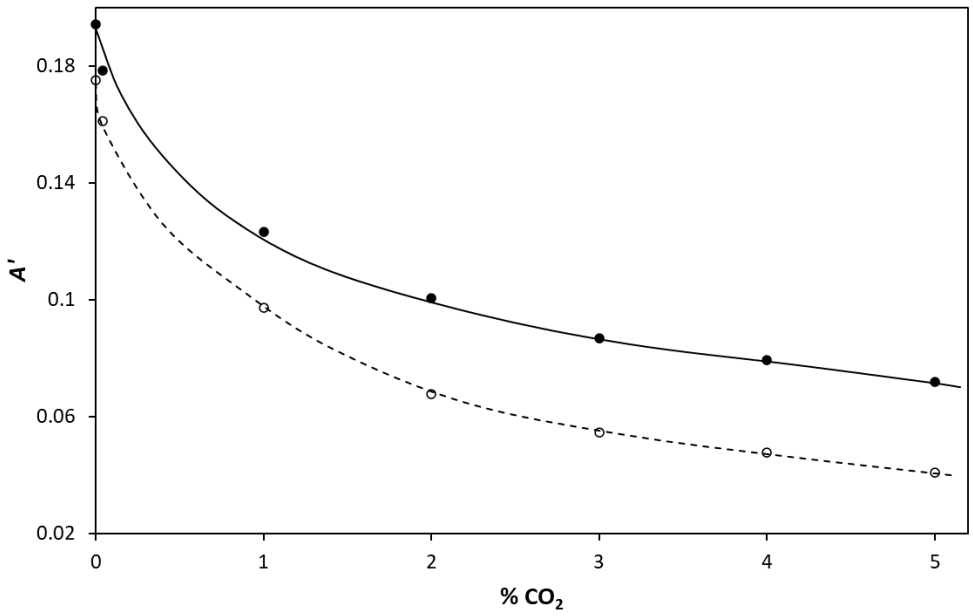


Figure S6. Plots of *A'* vs % CO_2 for (black circles, solid line) the lab-based and (open circles, broken line) the commercial CR-based capnography CO_2 indicators. Data from Table S4.

S6 A typical capnography waveform

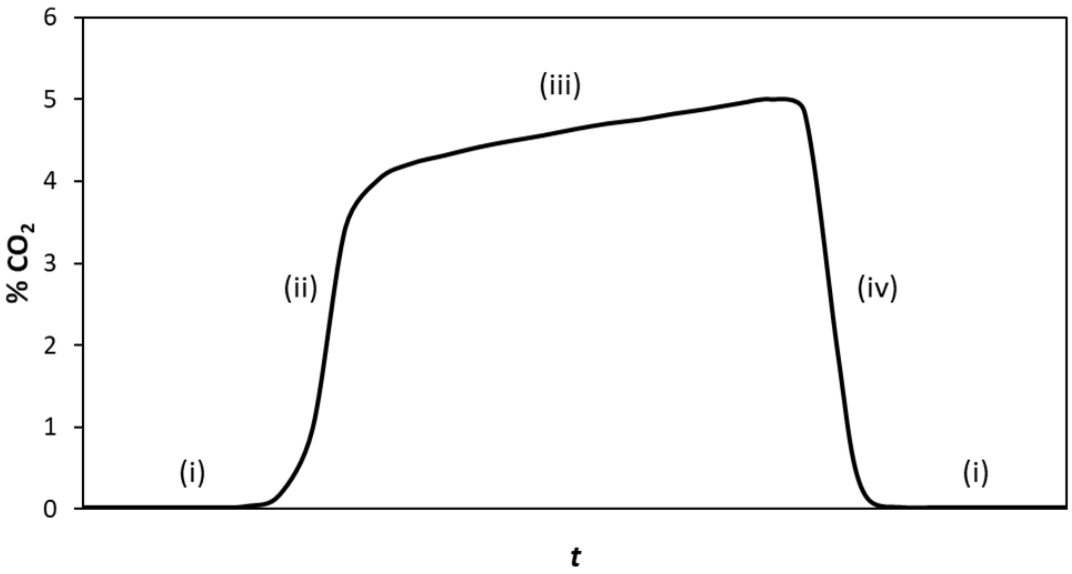


Figure S7. Normal capnography wave form with (i) inspiration flat phase, (ii) expiration upstroke, (iii) alveolar plateau and (iv) inspiration downstroke.