Development of a portable, distance-based paper analytical sensor for carbonate detection.

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In this study we transferred a laboratory-based titration reaction for carbonate determination onto a portable paper-based analytical device (PAD). The carbonate quantity can be read out by measuring the distance of a colour change along a paper-based reaction channel. Device dimensions and detection reagent constituents were optimized to enable detection of carbonate ions in the range of 0 – 1000 mg L^{-1}. The PAD featured a reaction channel in hydrophilic filter paper defined by a hydrophobic wax barrier. The detection reagent consisted of citric acid/citrate buffer (0.5 M, pH 2.5), bromocresol green (BCG) indicator (0.10% w/v) and PDADMAC (5.0 % v/v) dissolved in 20% ethanol. The base of the device was sealed with tape to prevent reagents leaking. Sixty microlitres of carbonate sample were added to the base of the channel and the liquid was allowed to wick up the channel. Colour development occurred as the carbonate ions reacted with the hydronium ions in the detection reagent resulting in a colour change of the BCG indicator from yellow to blue.

To optimise the reaction channel, two dimensions were compared, 1 mm x 30 mm and 2 mm x 30 mm. The device with the wider channel gave a higher colour intensity between carbonate concentrations 0 – 200 mg L^{-1}. In this range the sensor gave a linear response. The effect of filter paper pore size was investigated to study wicking time. Whatman 4 paper (pore size 23 µm) had a six times faster wicking rate of 7 min compared to Whatman 1 (pore size 11 µm) with 42 min. Reproducibility studies (100, 200, 400, 500, 600, 800 and 1000 ppm carbonate, n = 6) gave a maximum RSD of 2.4% showing consistency across the range of samples tested. Interference tests were conducted with 500 ppm CO_3^{2-} with additional environmentally occurring ions, i.e. 250 ppm SO_4^{2-}, 250 ppm Cl^- or 50 ppm of NO_3^- (F=1.924<Fcrit=3.411). There was no significant interference found from these ions.

Future work will focus on packaging and sealing the devices for on-site use, benchmarking with real environmental samples and in-the-field use with by minimally trained personnel.