

A centrifugal microfluidic platform for Chromium speciation on a lab-on-a-disc.

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The quantitative analysis of chromium species is referred to as chromium speciation. While chromium exists in oxidation states from 0 to VI, it is predominantly found in the (III) and (VI) states [1]. Industry effluent (e.g. textile/electroplating) is a common source of chromium pollution in the environment. Due to corrosion inhibitors used in pipes, and contamination leaching from sanitary landfills, drinking water supplies can become contaminated also [2]. The bioavailability and toxicity of chromium is largely dependent the oxidation state of the element [2]. Consumption of Cr (III) is an essential component in human diet, as it is responsible for maintaining glucose, lipid and protein metabolism [3]. In contrast, Cr (VI) is strongly oxidizing, exhibiting high toxicity, with carcinogenic and mutagenic properties [4]. It is recommended by the World Health Organisation (WHO) that the maximum allowable concentration of chromium (VI) in drinking water is 0.05 mg L⁻¹ [5].

Herein, describes the development of a centrifugal-based microfluidic device (CMD) optimised for the quantitative analysis of both chromium (III) and (VI) species in water. The CMD platform is inclusive of a centrifugally-driven lab-on-a-disc (LOAD) cartridge with a complementary 3d printed colourimetric sensor system with heating and results read-out capabilities. For analysis, the sample is loaded into a reservoir on the disposable microfluidic disc, along with reagents. Due to the low viscosity of the reagents, a microfluidic 'shield-shaped' reservoir was designed for the prevention of premature liquid flow. A centrifugal force is then obtained, through the spinning of the disc, for liquid pumping through microchannels, causing them to mix and react to form a coloured product into the optical-pathway detection zone, as previously reported [6]. In this case however, as two analytes were being assessed, a preferred path length of 50mm was selected to allow both samples to be run in duplicate. The incorporated optical detection system consisted of a light emitting diode (LED) and photodiode (PD) couple. Chromium (III) and (VI) were measured using 2,6-pyridine dicarboxylic acid and 1,5-diphenyl carbazide (DPC) respectively, forming complexes that were measured at 535 nm. The LOD for trivalent and hexavalent chromium using this device were 21 mg L⁻¹ and 4 µg L⁻¹, respectively. The linear range for quantitative analysis was found to be 69–1000 mg L⁻¹ for Cr(III) and 14–1000 µg L⁻¹ for Cr (VI). The device is simple to use, low in cost solution which could provide rapid on-site measurements comparable with standard benchtop spectrophotometers.

References:

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