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A conjugated mess: measurements of benzene (C_6H_6), CH_4, CO_2, and H_2O using a cavity ring-down spectrometer

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Benzene is widely used carcinogenic chemical that ranks among the top 15 chemicals produced in the world by volume. It is part of many industrial processes from solvents to rubber and drug production and is also produced in petroleum refinement and use. OSHA and European regulators have set a strict long-term exposure limit and short-term exposure limit of 1ppm and 15ppm, respectively, to minimize hazards to a person's health. With the recent passing by the EPA of mandatory fence line monitoring of benzene at petroleum factories, it is evident that a robust, continuous measurement of benzene is necessary. Conventional measurements of benzene suffer from a high granularity (nearly 1 ppm), cumbersome sample preparation/processing, or cross-sensitivities from other gas species. The aim of this study is to show development of an analyzer using cavity ring-down spectrometry (CRDS) to measure benzene, as well as all the main constituents of air that can influence a measurement: H_2O, CO_2, and CH_4. A measurement of benzene to an uncertainty of 100 ppb in $<$5 minutes is currently attainable, with a future goal of making this measurement in only ten seconds to 1 minute. Initial results show precisions of CH_4 at 0.5ppb, CO_2 at 0.5ppm and H_2O of 10ppm. Because of the relatively IR-inactive C_6H_6 molecule, only broad features lying underneath the relatively sharp signals of CH_4, CO_2, and H_2O can be used to quantify benzene concentrations. The stability of the CRDS analyzer allows us to look at structured changes in the baseline due to benzene to get out a precise measurement, while rarely having to do a zero-reference calibration. The analysis of these four species yields an instrument that is not only viable for fence line monitoring of petroleum refineries, but one that could also be used for local atmospheric monitoring of cities or even gas-stations.