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A Raman Effect-Based Approach to Hydrogen Detection

Hydrogen is increasingly being considered as renewable energy carrier. This interest is driven by its favorable properties: it is lightweight, storable, highly reactive, has a high energy content per unit mass, and can be produced on an industrial scale. Along its lifecycle, it is essential to: (i) ensure compliance with regulatory requirements; (ii) optimize the efficiency of equipment (e.g. energy conversion); (iii) guarantee safety in environments. Various measurement techniques are employed depending on specific requirements, such as sensitivity, response and recovery times, measurement range, and resistance to cross-sensitivity with impurities.
In the analysis of gaseous samples, Raman spectroscopy offers a non-invasive approach, requiring only a laser beam to pass through the sample and optical windows to collect the scattered light [1,2,3]. A Raman system designed for the detection of hydrogen, nitrogen, and oxygen is presented. The system utilizes a non-dispersive approach, wherein the Raman scattering signals of the three target molecules are selectively detected using different band-pass filters. The performance of this design is compared to a dispersive approach, which employs a diffraction grating spectrometer to analyze the spectrum. The Raman emission is triggered by a 532nm DPSS Nd:YAG laser source with an optical power of 1.5W and both systems are characterized by sample pressures (1-3 bar) and camera integration times (2 – 10 s).
The H_2 LODs are 345 ppm and 980 ppm for the non-dispersive and dispersive approaches, respectively (sample pressure: 1.5 bar, camera integration time: 2 s). By increasing the sample pressure and camera integration time, the LODs decrease accordingly to 40 ppm and 135 ppm (3 bar and 10 s) for the non-dispersive and dispersive approaches, respectively. Moreover, the advantages of the non-dispersive configuration include a simplified design, reduced use of optical and mechanical components, and easier assembly and alignment.

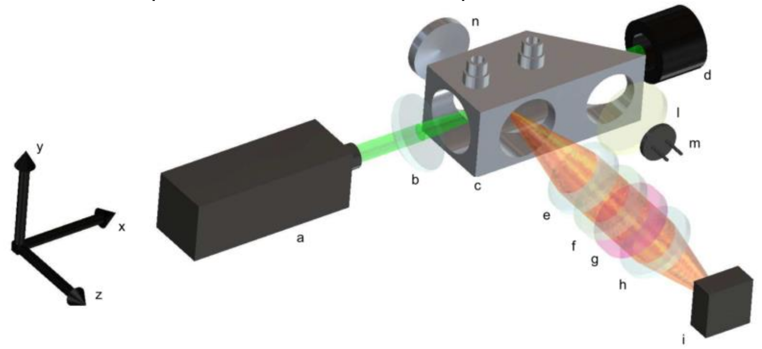

Figure 1: System schematic. a) laser source. b) focusing lens. c) gas cell. d) beam dump. e,h) colleting lenses. f) long-pass filter. g) band-pass filter. i) camera. l) diffuser. m) photodiode. n) back-reflection mirror.

References

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