In order to determine the best achievable sensitivity of the QEPAS sensor we performed an Allan deviation analysis, measuring and averaging the QEPAS signal for pure N_2 at 160 mbar pressure under the optimized QEPAS operating conditions. As shown in Fig. 6(b), for a 1 s integration time a C_{min} = 1.3 ppm is reached, which, for averaging times of 3.5 s, drops down to 450 ppb, a record value for H_2S optical detection. The latter corresponds to a minimum absorption coefficient $\alpha_{min} = 3.5 \cdot 10^{-8}$ cm^{-1}. By taking into account the laser power available for sample interaction (~45 mW due to partial reflection by the ZnSe entrance window of the vacuum-thigh cell), we extract a NNEA of $7.3 \cdot 10^{-9}$ $Wcm^{-1}Hz^{-1/2}$.

5. Conclusion

In this work we have reported on a widely-tunable QEPAS spectrometer operating around 8 μm wavelength based on a single-mode fiber-coupled EC-QCL. The HWG allows to clean the astigmatic beam exiting the QCL into a TEM_{00}-like mode, optimal for beam focusing through the QTF. Moreover, the use of a hollow-core fiber allows to fully exploit the wide tunability of the laser source, avoiding any optical misalignment with the ADM module produced by mechanical rotations of the external-cavity grating. Spectroscopic validation of the sensor has been carried out selecting as target gas H_2S, a toxic molecule of crucial importance for petrochemical and environmental monitoring applications. Background-free spectral scans for different H_2S concentrations have been performed in order to verify the sensor linearity. The sensor allows for rapid measurements (200 ms integration time) down to a detection limit of 3 ppm of H_2S in N_2. The sensitivity can be improved by about one order of magnitude (330 ppb) by increasing the integration time up to ~30 seconds. Noteworthy, at the operating pressure of 160 mbar the selected absorption H_2S line is not sensibly affected by the presence of water vapors (up to few %) in the gas mixture and make our sensor usable for in field on-line H_2S measurements.

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