TATP gas phase detection for security applications based on mid-infrared absorption spectroscopy

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Short abstract: Terrorist attacks with improvised explosive devices (IEDs) severely threaten public safety making it essential to develop appropriate detection systems for early countermeasures. Mid-infrared absorption spectroscopy is a promising technique for detecting volatile explosives. Here, we present an approach to build and evaluate such a system for security applications.

Triacetone triperoxide (TATP) has been used in various terrorist bomb attacks, as it is easy to synthesize from common chemicals [1]. It is a powerful and unstable explosive and highly sensitive to heat, friction, and shock, making it a significant security threat. To prevent such incidents of bombings or other attacks, a reliable early detection of volatile explosives, like TATP, is essential [2]. Mid-infrared (MIR) spectroscopy is particularly useful for detecting TATP because it shows distinct and identifiable absorption peaks due to molecular vibrations of the functional groups [3]. Non-destructive testing using MIR spectroscopy allows for the rapid screening of materials without causing any damage to the items being inspected, making it an ideal method for detection in a variety of real-world environments [4].

In this work, we present pre-measurements to detect TATP based on a mid-infrared laser spectroscopic setup which is especially tailored for security applications. Herein a broadband tunable external cavity quantum cascade laser (910cm^{-1} - 1490cm^{-1}) is used for the proof of concept study in combination with different types of multipass cells for measuring the characteristic fingerprints of TATP. To address the field applicability, we developed a special doormat with a suction unit underneath that is directly connected to the optical multipass cell. This allows to check persons for TATP residues on shoes while entering certain (restricted) areas (Fig. 1).

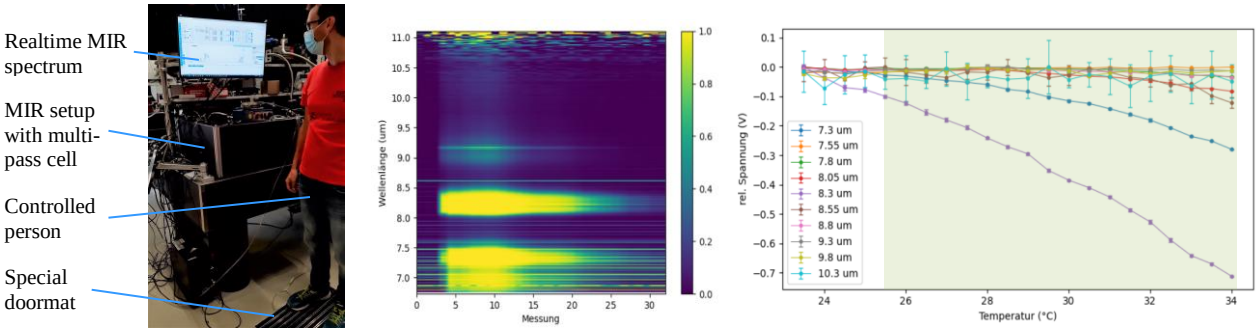

Fig. 1 Left: Measurement setup in the laboratory. The developed doormat with a special suction unit is placed on the floor and simulates an access point. Center: Temporal development of the MIR signal in the proof of concept study with acetone. Right: Temperature dependence tests with TATP.

Firstly, we verified the operability and reliability of our spectroscopic system: For this we measured the absorption of sublimating TATP in a controlled environment to obtain a dependence of absorption on temperature and pressure. So far for a reliable detection of TATP with our system a heating slightly above room temperature is needed. Secondly, we have tested our designed doormat by applying a liquid acetone solution onto shoe surfaces serving as a typical precursor of TATP. We were able to demonstrate that we can achieve a very fast response time with our setup although the recovery time after leaving the doormat is subject of further improvements.

Our first results form a fundamental approach for the design of a laser-based volatile explosive detection system for the practical application in security environments. An optimized system can serve as a model technology and opens a window for early countermeasures.

References

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