RAMAN BASED BOTTLE SCREENER FOR CONCEALED HAZARDOUS LIQUIDS

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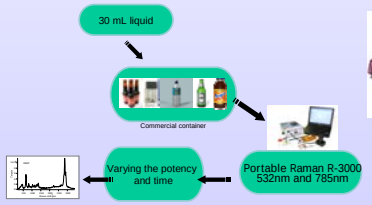
Introduction

Current regulations for the transportation of liquids in commercial aircrafts are based on the possibility to hide dangerous liquids in common liquid containers such as drinks or personal care products. These concealed liquids can then be used as a threat to people and property in the air or in land. The establishment of these regulations also recognizes the challenges of detecting dangerous liquids when hidden or mixed within common non dangerous products. This research evaluates two non invasive, non destructive detection approaches that can be used to characterize the content of common liquid containers and detect if the liquid is the intended or a concealed hazardous liquid. Fiber optic coupled Raman spectroscopy and Standoff Raman spectroscopy were used to inspect the content of glass and plastic containers. Raman spectroscopy experiments were performed at 532, 488 and 785 nm excitation wavelengths. The hazardous liquids under consideration included chemical warfare agent (CWA) simulant DMMP, hydrogen peroxide, acetone, cyclohexane, ethanol and nitric acid. These techniques have potential use as a detector for hazardous liquids at a check point or to inspect suspicious bottles from a distance.

Experimental

Fiber optic based detection



Standoff Raman Detection

Distance: 7 meters

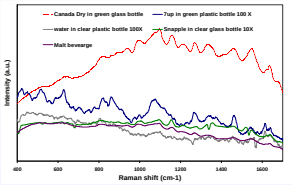
Laser: 488 nm

Laser power: 0.6 W

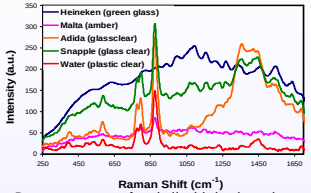
1 accumulation

Results

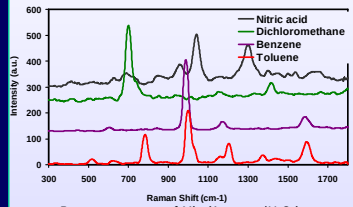
Fiber optic based detection



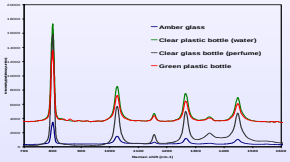
Raman spectrum of soft drinks acquired with fiber optic 780 nm spectrometer



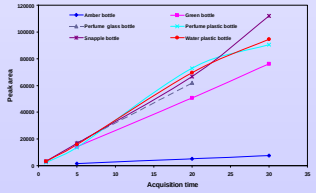
Raman spectrum of toxic liquids in clear glass bottle at 532 nm. 1 sec and 100 mW laser power.



Raman spectrum of Mix (Acetone/H_2O_2) at 785 nm, 1 s and 100 mW laser power.



Cyclohexane in different bottles 785 nm, 5 s at 200 mW



Detection of acetone in different bottles at 532 nm and 18 mW

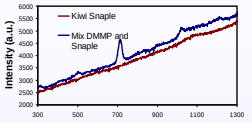
Green glass bottle	14.1 mW	22.1 mW	28.1 mW
50%	1.36	1.11	0.683
25%	2.82	2.22	0.825
15%	3.41	2.63	1.11
5%	3.69	2.99	1.64
Amber glass bottle			
50%	3.07	2.81	2.51
25%	N/D	N/D	N/D
15%	N/D	N/D	N/D
5%	N/D	N/D	N/D
Clear glass bottle			
50%	0.969	0.687	0.451
25%	1.01	0.810	0.574
15%	2.26	1.72	0.945
5%	2.75	2.54	1.33

Limits time of detection for the mix (DMMP/H2O) at 532nm

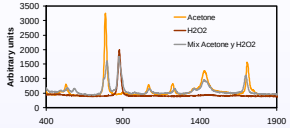
A variety of flammables, TICs and CWAs were detected in commercial clear, green and amber bottles. DMMP, a CWA simulant was detected in water containers at concentrations below 5%

Cont. Results

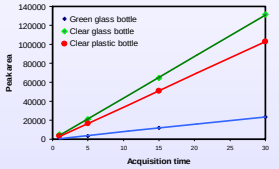
Standoff Raman Detection



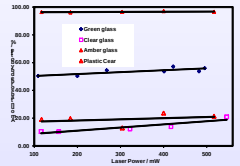
Mix of DMMP (CWAS) in Kiwi Snapple: 1 acquisition of 30 s



Mix of acetone and H_2O_2 in a Snapple clear glass bottle 1 acquisition of 10 s



Detection of DMMP in different bottles 0.5 W with a 488 nm laser



Effect of bottle material on the amount of radiation absorbed by the walls

Detection was limited more by container color and thickness than by liquid color. However this can be overcome by changing laser frequency and intensity.

Path forward

Generate Raman library of common liquids with variables representing real field conditions (temperature, concentration and aging).
Apply Chemometrics routines for enhanced detection and discrimination in colored liquids.

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