Application Note 12

Differentiation of common aircraft fluids.

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1. Introduction

The customer is interested in the detection of aircraft fluids leaking into the aircraft cabin. The goal in developing a method is to see if our sensors can discriminate between the headspaces of Jet A fuel, turbine oil, deicing fluid, hydraulic fluid and ethanol. Ethanol is a sample that is likely to be present in the cabin in the background.
The five samples the customer provided are Jet A fuel, Mobil oil, Castrol 399 oil, hydraulic fluid and deicing fluid (propylene glycol). The Cyranose 320 was used to analyze these samples and ethanol.

2. Experiment

Sample preparation:
The samples of Jet A fuel, Mobil oil, Castrol 399 oil and hydraulic fluid were sent in plastic bottles. All four bottles were in a metal can when they arrived. The deicing fluid (propylene glycol) was sent to us separately three weeks after. Ethanol was in our lab that we ordered from Aldrich (reagent, anhydrous, denatured). 1ml aliquots of each sample were placed in 20 ml vials, equipped with a septum seal. Ten replicates were prepared for each sample. All samples were kept in a laboratory environment at ambient conditions.

Testing Conditions:
A Cyranose 320 with a 32-sensor array was used to test these fluids. The instrument was warmed up for 6 minutes before the test. The method settings are in Table 1. The training set was obtained by sampling the 50 sealed vials randomly. The random order is listed in Table 2. A 1 1/2 inch, gauge 16 needle was used to pierce the septum and sample the headspace from the sealed vials while a 1 1/2 inch, gauge 16 needle was used for the vent. Samples were prepared one night prior to be sampled. Two sets of experiments were done with different grouping of these samples. First group included Jet A fuel, Mobil oil, Castrol 399, hydraulic fluid and deicing fluid. The second group included Jet A fuel, two oils as one class, hydraulic fluid and deicing fluid and ethanol.

Data handling:
Data was recorded with digital filter on. The sensor responses were calculated using the minimum of the resistance reading during the baseline purge and the maximum resistance reading during the vapor exposure, which is $(R_{max}-R_{min})/R_{min}$. The 32 sensor responses were then autoscaled and normalized. Canonical discriminant analysis was used to build the model and predict samples.

3. Results

All 5 aircraft fluids clustered into 4 distinct regions in PCA space (Figure 1), despite not controlling for laboratory air, which provided the baseline and carrier flow. The two turbine oils are not discriminated, as was expected by both Cyrano and the customer. Combining two turbine oils into one class, all 4 aircraft fluids and ethanol clustered into 5 different groups in the PCA space (Figure 2). The training process took about 1 hour and the training set of the second group with ethanol lasted at least 31 days for correct identifications of these 5 samples.

4. Conclusion

Analysis with a Cyranose created distinct patterns that allowed samples of Jet A fuel, turbine oil, hydraulic fluid, deicing fluid and ethanol to be identified easily. Sample preparation and building the training set was quick and easy.
From the results, we can see that the unique polymer composite sensors can readily differentiate these aircraft fluids and ethanol. The study clearly demonstrates the potential of using Cyranose Sciences array of polymer composite sensors to monitor leaks in aircraft cabins, chemical plants, refineries, and confined spaces.

Table 1. Screen shot of the method setting used in the experiments.

Method name	Fuels and Oils	
Class 1	Octagon	
Class 2	Jet_A	
Class 3	Hydr_Fl	
Class 4	TurbineOil	
Class 5	Ethanol	
Class 6		
Baseline purge	10s	medium
Sample draw	10s	medium
Sample draw 2	0s	medium
Snout removal	0s	
1st sample gas purge	0s	high
1st air intake purge	5s	high

2nd sample gas purge	30s	high
2nd air intake purge	0s	high
Digital filtering	On	
Substrate heater	On	42
Training repeat count	1	
Identifying repeat count	1	
Active sensors	All	
Algorithm	Canonical	
Preprocessing	Autoscaling	
Normalization	Normalization 1	
Minimum confidence level		0

Table 2. Sampling sequence used in the training set, where A is Octagon, B is Jet A fuel, C is Hydraulic fluid, D is Turbine oil and E is ethanol.

1	A	1
1	A	2
4	D(Mobil)	1
3	C	1
4	D(Castrol)	2
3	C	2
5	E	1
2	B	1
1	A	3
3	C	3
3	C	4
3	C	5
1	A	4
2	B	2
5	E	2
2	B	3
5	E	3

5	E	4
2	B	4
4	D(M)	3
4	D(C)	4
5	E	5
4	D(M)	5
1	A	5
2	B	5
3	C	6
2	B	6
2	B	7
1	A	6
4	D(C)	6
1	A	7
5	E	6
2	B	8
1	A	8

3	C	7
5	E	7
4	D(M)	7
2	B	9
3	C	8
2	B	10
5	E	8
1	A	9
1	A	10
4	D(C)	8
3	C	9
3	C	10
5	E	9
4	D(M)	9
4	D(C)	10
5	E	10

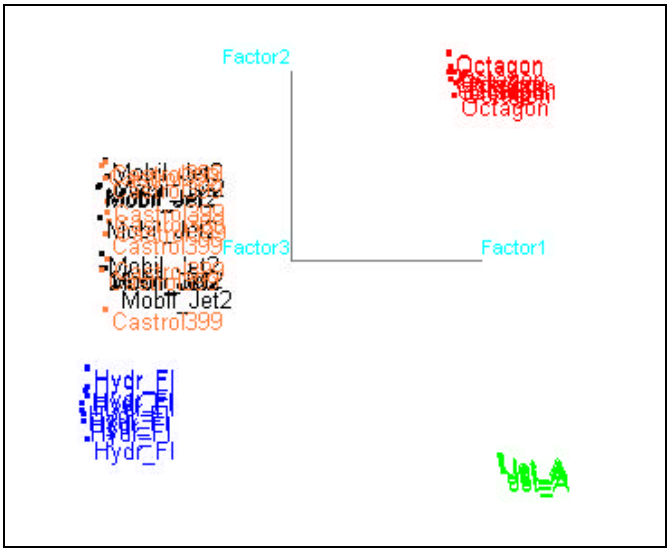

Figure 1 Plot of Principal Component Analysis (with Autoscaled and Normalization) Where Octagon is the deicing fluid.

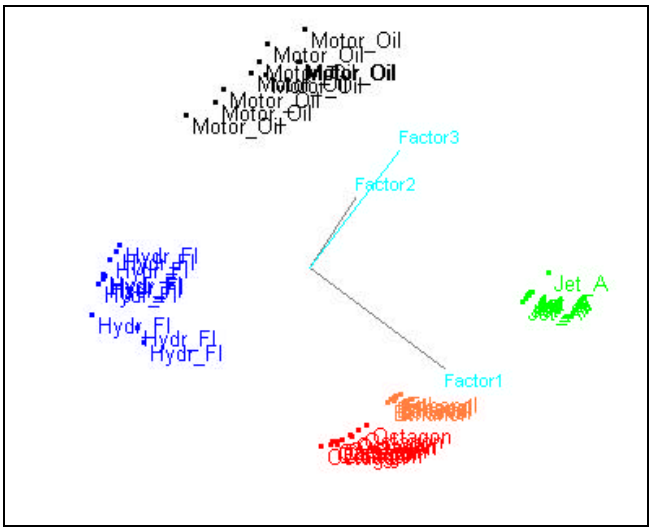

Figure 2 Plot of Principal Component Analysis (with Autoscaling and Normalization) Where Octagon is the deicing fluid.