Standard Method for Hydrogen Content in Fuels (ASTM D7171-05)

Application Note 14

The hydrogen content of aviation fuel is an important parameter as it determines the combustion properties of the fuel. Traditional methods such as smoke point, smoke volatility index and luminometer number are tedious, time-consuming and usually require skilled analysts. Nuclear Magnetic Resonance (NMR) offers the opportunity to monitor the hydrogen content of fuels rapidly, non-destructively and with minimal sample preparation.

Method

For 20 years, Oxford Instruments led the way with the Oxford 4000 Continuous Wave (CW) NMR Analyser, an American Society for Testing and Materials (ASTM) compliant instrument, for rapid and efficient measurement of hydrogen content in fuels.

Since CW instruments are no longer commercially available the previous ASTM standard method has been updated for the use of Pulsed NMR.*

In this method, the fuel samples are carefully transferred into glass tubes using a pipette, weighed and conditioned at 35°C or 40°C for 30 minutes prior to NMR analysis.

Note: Although this method was designed for aviation fuel, it can be adapted to suit distillates covered by other methods (e.g. D3701-01 and D4808-01) as well as those which are more volatile or have a high wax content.
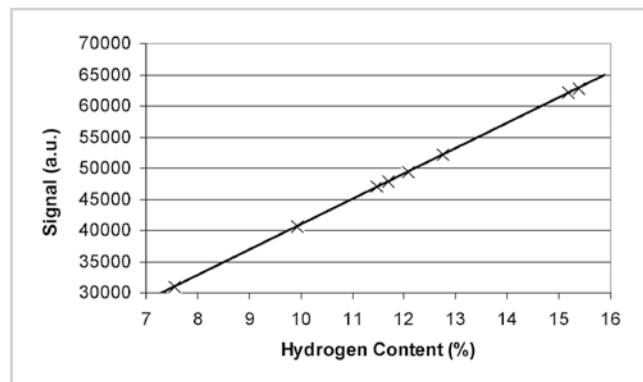

Figure 1: Hydrogen content calibration using hydrocarbons at 40°C

Advantages of benchtop NMR

- NMR is a very stable technique over the long-term and therefore requires little re-calibration

- Minimal sample preparation is required

- The NMR technique is non-destructive, so repeatability measurements can be made conveniently

- Sample measurement time is relatively short

Calibration and Results

The instrument can be calibrated using real samples of known hydrogen content which span the range of interest; a list of chemicals are recommended in the standard method.* In this example, the calibration was produced by using known masses of diethyl malonate, cyclohexyl acetate, ethyl heptanoate, octyl acetate, ethyl caprate, 2-nonanone, pentadecane and dodecane giving a correlation coefficient of 1.00 and standard deviation of 0.03. The predicted NMR results from this calibration are compared against the reference values in Table 1.

Sample	Ref. %wt H	NMR %wt H	Difference
Diethyl malonate	7.552	7.553	-0.001
Cyclohexyl acetate	9.924	9.946	-0.022
Ethyl heptanoate	11.466	11.510	-0.044
Octyl acetate	11.703	11.709	-0.006
Ethyl caprate	12.077	12.103	-0.026
2-Nonanone	12.756	12.749	+0.007
Pentadecane	15.185	15.227	-0.042
Dodecane	15.386	15.385	+0.001

Table 1: Accuracy for the hydrogen in fuel method which is primarily dependent on sample preparation

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Repeat	H Content (%)
1	12.757
2	12.757
3	12.752
4	12.739
5	12.730
6	12.737
7	12.745
Average	12.745 ±0.010

The precision of the experiment was checked by measuring a sample of 2-nonanone (12.756 %wt H) against this calibration curve, the results of which are shown in Table 2.

The results show that the method gives accurate and reproducible measurement of hydrogen content in fuels.

Table 2: *Precision of the hydrogen in fuel method*

Recommended Instrument Configuration

The **MQC**-23 with 0.55 Tesla magnet, fitted with an 18mm diameter (8 ml) sample probe is ideal for this application. The Hydrogen in Fuel package comprises:

- The **MQC**-23 which can be controlled using its own built-in computer using Microsoft® Windows® or via a stand alone PC
- **MultiQuant** software including **RI Calibration**, **RI Analysis**, and the **EasyCal** 'Hydrogen in Fuel' application
- 18 mm glass tubes
- PTFE stoppers (to seal the test cells)
- Stopper insertion/removal rod
- Installation manual
- Method sheet

In addition you may also wish to purchase:

- A dry heater and aluminium block with holes for conditioning the sample at 35°C or 40°C
- A precision balance

The instrument offers multiple advantages over other instruments on the market:

- High signal sensitivity
- Small benchtop footprint
- Low maintenance
- Minimal sample preparation

Note: Alternative methods/packages are available for other distillate samples although they may not be covered by this standard method. Please contact Oxford Instruments for further details.

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