Introduction to Hanby's Chemical Reaction Spectrophotometry ("CRS") and The Hydrocarbon ID

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CASE STUDY

RAPID RESPONDER: Hanby Kits Provide Real-Time Analysis in the Field

By: John D. Hanby, President and CEO, Hanby Environmental

Hanby Chemical Reaction Spectroscopy had its beginning with the observation in 1986 that a simple "spot" test method for aromatic compounds produced a strong color in the catalyst used in the reaction. The first application of the discovery was the development of a portable test kit that utilized a simple version of the method to perform environmental field test measurements of aromatics (Benzene, Toluene, etc.) and substances such as crude oils, fuels, solvents, etc. that contain these aromatic compounds. Two kits were designed for soil and water use. In March of 1989, both kits were used extensively during response efforts following the Exxon Valdez incident in Alaska. They were also widely employed in the large effort to discover and remediate the effects of the many leaking underground storage tanks that began in the 1970s.

Four fundamental actions necessary for effective response to accidental releases of harmful chemicals to the environment are analogous to typical responses to medical emergencies: 1. Stop the leak (stop the bleeding); 2. Assess the cause and overall extent of the container damage (what and where are the wounds); 3. Clean up the major sites of contamination (determine the major life-threatening trauma); and 4. Start initial clean up and remediation efforts (begin emergency and recuperative treatment).

Over 80 publications by the U.S. EPA since 1990 have noted the utility of Hanby Field Test Kits in rapid responses to environmental emergencies. One of the first, published by the Underground Storage Tank Division in September 1990, is entitled, "Field Methods: Dependable Data When You Need It." The report emphasized the accuracy, rapidity, and ease of use of the soil and water kits in the detection, removal, and cleanup of the thousands of leaking fuel tanks all over the United States. Of particular economy was the assistance to logistics planning for this massive effort.

In the winter of 1988 and the spring of 1989, two major environmental incidents occurred for which the Hanby kits performed these necessary rapid assessment duties. The first occurred at the Ashland oil storage tank facility. Approximately one million gallons of #2 fuel oil spilled over the protective burm surrounding one of the tanks and entered the Monongahela/Ohio river system. John Hanby was contacted to bring his kits to accompany a team comprising members of the EPA, the Ohio River Authority, and the West Virginia Wildlife Agency, which was pushing a barge load of sampling and analytical equipment up the Ohio River to determine the advance of the oil into the waterway. Only one other water analytical device had been provided on the equipment barge: a fluorescence spectrometer. When a generator failed on the tug/barge system, the Hanby water kits were the only available modality for the immediate analysis of the dozens of surface and water column samples that were being collected.

The second incident was the massive spill in Alaska caused by the rupture of tanks on the Exxon Valdez when the vessel grounded on Bligh Reef in Prince William Sound. One of the more immediate concerns was the pending release of millions of salmon from the hatcheries that were located around the Sound. When he met with Dennis Kelso, the Environmental Commissioner for Alaska, it was quickly decided to fly Hanby to three of the major hatcheries so that the release of the 2-in. hatchlings could be coordinated with relatively low levels of the oil at the release points. Water test kits were demonstrated to hatchery personnel and left at each of the facilities for the appropriate timing of the releases, which was indicated by tidal, current, wind, and other conditions in the Sound. It should be noted that subsequent harvests of these matured salmon set records and far exceeded the expected catch.

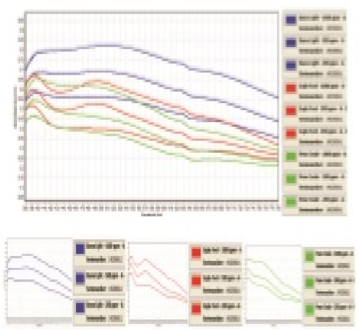
The obvious spectrometric potential of the method had been briefly examined in 1987 using a large bench instrument. The scans taken of a series of compounds and fuels revealed that broad-band spectra of these substances generated "fingerprint" signatures from the ultraviolet through the visible portion. Also, precise quantitative information was available.

Recently, Hanby has developed a portable device that utilizes a spectrophotometer to read the sample and provides spectral fingerprint identification (qualitative); the concentration level is determined by an area under the curve calculation (quantitative). These are depicted in the charts shown. This will be a paradigm shift for the way analysis is done for both the environmental and oil & gas industries, putting a laboratory in the field that has real-time analysis, providing the most accurate results possible.

These environmental uses of this new chemical reaction method continue and are soon to be augmented by the spectrometric device that the company has been developing for the past several years. The qualitative and quantitative precision available with this new technology, Chemical Reaction Spectrophotometry (CRS), is currently being closely evaluated by the petroleum industry for its potential for providing immediate data in exploration and production (E&P) to aid in more efficient, economical, and safe drilling. Also, in the past few weeks, much interest has been shown in this new technology by the Department of Oncology at a well-known cancer hospital in its development of molecular spectroscopic methods for cancer detection. For more inforation visit www.hanbyenvironmental.com.

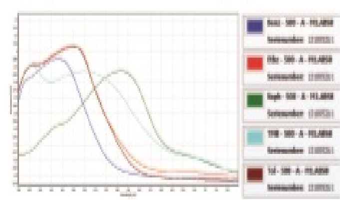
Chemical Reaction Spectrophotometry (CRS)

Hydrocarbon ID



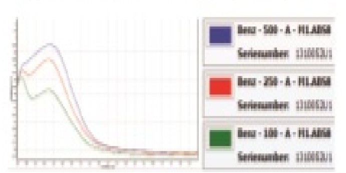
Aromatics – *Qualitative*

Fingerprint Identification – By Spectral Curve



Aromatics – *Quantitative*

Concentration – By Area Under Curve



FRONT & CENTER

Hanby Environmental

The Utilization of Strong Chemical Reactions to Enhance the Spectral Signature of Petroleum Substances Chemical Reaction Spectrophotometry

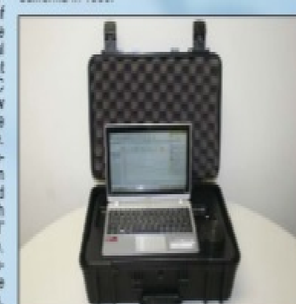
By: John D. Hanby

A new method for the spectral analysis of petroleum compounds in the environment is described that utilizes a combination of chemical (bond) energy and UV/vis light energy.

The correspondence of chemical bond energy levels (10^{4}-10^{5} Cal/mol) with UV/visible frequencies (10^{14}-10^{15} cps) results in a robust spectral resonance that provides a new spectrophotometric technique for the qualitative and quantitative analysis of complex organic substances such as crude oils. Particularly strong spectral signals in the UV/vis region are produced by certain chemical reactions. This strong spectral energy is related to the electronic population inversion achieved in the course of these exothermic chemical reactions, which is in line with the definition of a chemical laser as "*a laser operating on a population inversion produced—directly or indirectly—in the course of an exothermic chemical reaction.*"[1]

The discovery of the analytical capability of this technique was made by the author shortly after he left a 10-year position as Environmental Health Lab Supervisor at NASA, JSC, Houston in 1985. One of the methods for the analysis of Space Shuttle drinking water was the visual determination of the disinfectant used, bromine, utilizing Nessler tubes. The significance of this new technique lies in the enhancement of the signal-to-noise ratio (SNR) resulting from the strong spectral signals achieved by specific chemical substances, particularly aromatics, that are present (3% to 30%) in crude oils and readily undergo the FC reactions. This is analogous to having relatively few "marker compounds" present in a complex substance that provide definitive identification of the substance. Crude oil, petroleum, is the most complex organic substance on the planet. This is understandable given that it is derived from the biota that have accumulated on the earth for about 100 million years and, through sedimentation and geological processes, has "cooked" at high temperature and pressure through this time. Accordingly, the precise, definitive analysis of the hundreds of components in petroleum, or "TPH," is the most daunting task facing environmental chemists. Hanby patented a field test kit for water and soil samples that utilized the discovery in 1991.

Spectrometry is based on the fact that certain electronic configurations in molecules undergo harmonic resonances with specific frequencies in the electromagnetic spectrum. These frequencies range from extremely powerful energies such as X-rays to relatively low-energy frequencies such as microwave and infrared (heat). Ultraviolet and visible (UV/vis) frequencies have precisely the frequencies that resonate with the electronic structures of molecules. This spectral resonance is captured by the field device, called "Hydrocarbon ID," and compared with a spectral library stored in the computer of the device. These bonds are composed of electron pairs that strongly resonate with UV/vis spectral energy especially when the newly formed products, called chromophores, are still in close contact (adsorbed) with the catalyst. The first publication concerning this new utilization of the relationship between spectral energy and chemical energy was first described by Hanby in the proceedings of an environmental conference held in Newport Beach, California in 1990.



[1] Gross, R.W. 1976. *Handbook of Chemical Lasers*. New York: John Wiley and Sons.