Paint Data Query (PDQ)

A Database in the Making

❖ Studies conducted more than 35 years ago by RCMP forensic laboratories showed that vehicles could be differentiated by comparing the colour, layer sequence and chemical composition of each individual layer in a paint system.

❖ As with any case involving an unknown, in order to help identify its source, it is important to have a large collection of data in the form of a searchable database.

❖ To make those comparisons possible, a comprehensive database was developed as well as a means of searching and retrieving the information.

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Paint Data Query (PDQ)

❖ By 1996, PDQ was created and began to grow internationally with the support of SWGMAT and the FBI, followed by financial support from NIST.

❖ Today, PDQ is an international automotive paint database used by forensic scientists in 102 forensic laboratories located in 24 countries (including 58 forensic laboratories in 32 states in the United States) to help identify possible suspect vehicles based on paint evidence left behind at the scene of a crime.

❖ PDQ can also be used to help determine how unique a paint system is as well as a learning tool to stay abreast of new paint formulations and trends in the automotive paint industry. (PUR, OU1 vs OT2)

PDQ contains over 21000 samples (~ 85000 layers)

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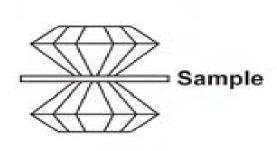Mounted Police   du Canada

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Structure of a Paint System

❖ The paint systems of an automobile typically have three or four layers; a clear coat, over a topcoat, over one or more undercoats.

❖ Automotive manufacturers use paint layers from various paint manufacturers, where each layer has a combination of binders and pigments.

❖ These variables often create unique combinations that allow forensic scientists to determine the possible make, model and year range for a vehicle from which a paint chip may have originated.

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The Analytical Method

❖ Each paint layer is separated and placed between two diamonds for infrared analysis. Each component has a characteristic fingerprint known as an infrared spectrum.

Binders
Epoxy
Isophthalic Alkyd
(polyester)

Pigments
Titanium Dioxide
Strontium Chromate
Aluminum Silicate
Barium Sulphate

Sample

Sample Analysis ⟶ Instrument Data ⟶ Paint Composition

The PDQ Program

❖ The PDQ program is comprised of three components:

- ▪ PDQi text based database (upgraded to VB.net platform 2013)
- ▪ PDQ Spectral Library (Bio-Rad, KnowItAll)
- ▪ PDQ Help Line

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PDQi Software

❖ PDQi is a text based database on Visual Basic (VB.net) platform.

❖ PDQi contains the complete source information for each sample along with layer sequence information including colour descriptions, chemical composition of each layer as well as images of each spectrum.

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PDQi Records

Searching PDQi

❖ The layer sequence and chemical composition derived from the examination and analysis of an unknown paint chip is entered as a minimum search parameter.

❖ The software searches the database, comparing all records for samples having similar paint system to the unknown, generating a 'hit list' of vehicles. The 'hit list' is a list of vehicles that are similar in layer sequence and in chemistry to the unknown.

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PDQ Spectral Data

❖ Samples are analyzed by the PDQ Maintenance Team, this ensures consistency in spectral acquisition and spectral coding.

❖ Spectra are acquired using Thermo Scientific Nicolet 6700 FT-IR spectrometers equipped with air cooled source, cesium iodide (CsI) beamsplitter, deuterated-triglycine sulfate (DTGS) detector to give an extended range from 4000-250cm^{-1}.

❖ FT-IR Performance tests including signal alignment, collection of background, 100% lines and CO2 or polyurethane tests are done daily/monthly.

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❖ Each spectrum title contains key information which identifies the PDQ number, layer sequence, colour description or munsell value, manufacturer, plant, year, substrate and category (clearcoats, basecoats, primers, ecoats and substrates).

UCAD00299 OT2 CLEAR   N HON MAY 2015 MET CC
UCAD00299 OU1 5PB   8.0 1 HON MAY 2015 MET PC

Spectra Titles

UCAD00299 OT2 CLEAR   N HON MAY 2015 MET CC
UCAD00299 OU1 5PB   8.0 1 HON MAY 2015 MET PC

PDQ Number

Layer Sequence

Hue or Colour Description

Value

Chroma

Manufacturer

Plant

Year

Substrate

Category

This information is converted to individual property fields when creating the spectral library using *KnowItAll*™

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Searching PDQ Spectral Libraries

❖ Property fields can be searched individually or in combination with other property fields.

❖ Unknown spectra can be searched against the library individually or in combination with any number of property fields.

❖ Sub-libraries for each category were created to allow more accurate search results within KnowItAll.

❖ Spectra are identified by their substrate to allow searching against paint systems from plastic substrates or metal substrates.

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PDQ Spectral Library

❖ The PDQ Spectral Library is created from raw data using Bio-Rad's KnowItAll software

❖ The spectral library contains FT-IR spectra for each layer of a known paint system found in the PDQ database.

❖ Database hits from a 'hit list' can be confirmed or excluded by comparing the infrared spectra of each unknown paint layer against the spectra in the library for the corresponding entry.

❖ Hits that remain on the 'hit list' are those that are indistinguishable from the unknown. With this information, a list of possible makes/models/ and year range can be determined.

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PDQ Help Line

❖ A member of the PDQ Maintenance Team is available to assist our partners with

- Software installation
- Spectral Coding
- PDQi searches
- Spectral searches
- Consultation
- Opinion reports

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Partnership Model

❖ PDQ Partners must
  ❖ be from a recognized law enforcement agency*
  ❖ sign a non-disclosure confidentiality agreement
  ❖ agree to contribute 60 OEM automotive paint samples annually in exchange/payment for the database

❖ A PDQ release is issued each fall with a minimum 500 additional samples

*Access to the database or sharing of some data or information may be granted to non law enforcement agencies for research purposes.

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Obtaining Samples

❖ Partners are asked to collect samples in their area from vehicles no older than 6 model years. This ensures new data is available every year.

❖ Partnership model benefits include having laboratories around the world collecting and submitting samples.

❖ The automotive industry is a global market. For example, samples collected in other countries and continents are often still valuable to those using the database in North America and vice versa.

> ❖ Mitsubishi, Toyota and Nissan vehicles marketed in Australia have been found to have comparable paint systems to those same or corresponding vehicles marketed in North America.

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❖ The PDQi program allows Partners to enter the source information of samples being sent in a submission. Many fields provide a drop down menu to help increase the accuracy of the information.

❖ Entering source information creates a Temporary (T) number in PDQ. Once all samples are entered, the program will export all T numbers into a spreadsheet. We use this to verify information.

❖ Partners also create an update file (zip file) containing their sample submission data to send with their spreadsheet to the PDQ MT.

❖ Zip files are uploaded into our PDQ Maintenance Team master version of the software via a TOOLS tab not available on partner versions of the software.

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Populating with intention

❖ With such a large pool of samples to select from each year, the database is strategically populated trying to achieve diversity in samples and in chemistry

❖ Samples are intentionally selected so that every paint system is represented; the goal is to analyze 5 samples from every plant for every year of manufacture.

❖ Samples received are sorted into 2 primary categories, samples older than 6 model years are converted to Star (*) samples and filed by submitting laboratory; Samples 6 model years or newer are searched against the database.

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❖ First priority is placed on newest samples or any samples from plants or years that aren't currently in the database including rare vehicles.

❖ Second priority is given to any samples containing a red, white or black topcoat, or any other colour where a colour coordinated primer may be in use.

❖ Third priority is any sample that populates a plant and year with less than 5 samples.

❖ Those that deemed to be duplicates not suitable for analysis or older than 6 model years are converted to * samples and are catalogued numerically.

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Storage of Samples

❖ Samples come as Temporary records, created by our Partners. In PDQi, Temporary records reflect our inventory, they are waiting analysis or conversion to a * sample.

❖ Samples submitted that are older than 6 model years, are aftermarket refinishes, have incomplete OEM systems, are not suitable for analysis (too small or too brittle) or are duplicate samples are converted to * samples.

❖ Samples that are analysed for inclusion in the database are assigned a PDQ Number.

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Processed PDQ Samples are stored in Stanley® Vidmar™ cabinets.

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Maintenance of PDQ Program

❖ Maintaining contact with all Partners

❖ Receiving sample submissions

❖ Selecting samples for analysis to achieve diversity in the database

❖ Acquiring quality spectra

❖ Ensuring consistency in spectral coding

❖ Cataloguing samples

❖ Research into new plants

❖ Providing training and support to Partners

❖ Updating the software and spectral libraries for distribution

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How often is the data accessed?

❖ PDQ*i* has a function built into the software that records the number of times a user executes certain functions within the software, however, the fact that PDQi is used as a standalone program on one or more computers within a given partner agency prevents us from collecting reliable usage data.

❖ Giving access to our partners via a secure webportal would allow us to collect accurate usage data, but we have yet to find an agency to host the database on a secure webportal.

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Administrative Challenges

❖ Receiving sample submissions by the given deadline (electronic files must be uploaded into the software before the update can be created)

❖ Ensuring quality OEM samples are collected and submitted by our partners

❖ Selecting samples with intention to achieve diversity in sample population

❖ Submissions completed properly, organized, correct envelopes

❖ Maintaining contact with each PDQ Partner

Collaborative Exercise

❖ The PDQ MT along with direct supervisor Dr. Mark Sandercock applied for the 2014 ASTEE research grant to conduct a collaborative exercise to examine the ability of forensic scientists to search PDQ to identify a possible make and year of an automotive paint sample.

❖ A suitable manufacturing plant was selected and an automotive part (trunk) was purchased. Partners received automotive paint chips to analyze by FT-IR, perform spectral interpretation, search PDQi and the spectral library using KnowItAll. Results were received, reviewed and the data was compiled to write an article of the findings.

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Collaborative Exercise

❖ 45 participants from 35 different forensic laboratories in 9 different countries participated in the collaborative exercise.

❖ International participation; Canada, US, Australia, Europe

❖ 87% of participants who submitted their results obtained the correct answer.

❖ Confirmation that our PDQ partners are able to successfully search the database

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Future Improvements

❖ Having PDQ available online would allow immediate access to updated information and would allow us to track usage more accurately.

❖ A secure website where PDQ data updates could be downloaded would allow more than one update per year, eliminate the time to prepare a release as well as eliminate the cost of materials and shipping.

❖ Adding Munsell values for topcoats in PDQi similar to NAPF.

❖ Additional research into plants such as Japan and Ulsan where multiple plants are in use producing multiple lines.

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