Conducting Motor Vehicle Make-Model-Year Searches Using the Paint Data Query (PDQ) Databases

1 Introduction

Paint Data Query (PDQ) is an automotive paint database that contains information about the factory-applied topcoat and undercoat (primer) paints applied to most imported and domestic vehicles marketed in North America. It is reserved exclusively for law enforcement agencies involved in forensic investigations. As a sourcing tool, PDQ can be used in conjunction with other automotive paint collections such as refinisher color chips and the FBI Laboratory's National Automotive Paint File (NAPF).

2 Scope

This general procedure applies to Chemistry Unit caseworking personnel who use the PDQ databases for motor vehicle make-model-year searches. Users receive hands-on training to learn how the database is designed, how to characterize and code various paint systems, and to gain the basic interpretive skills necessary to effectively evaluate the search results.

3 Equipment/Materials/Reagents

a. (Automotive) Paint Database Query (PDQi) program, current update (Royal Canadian Mounted Police, PDQ Maintenance team, Edmonton, Alberta, Canada)

b. PDQi User's Manual, current version will be contained within PDQi program

c. PDQi Code Book, current revision (Royal Canadian Mounted Police, PDQ Maintenance team, Edmonton, Alberta, Canada)

d. PDQi Contents Manual, most current revision (Royal Canadian Mounted Police, PDQ Maintenance team, Edmonton, Alberta, Canada)

e. PDQi Spectral Libraries, current revision (Royal Canadian Mounted Police, PDQ Maintenance team, Edmonton, Alberta, Canada)

f. PDQi Spectral Information Manual, current revision (Royal Canadian Mounted Police, PDQ Maintenance team, Edmonton, Alberta, Canada)

g. Bio-Rad Know-It-All spectral search software, current revision

h. PC with operating system and specifications as recommended by the PDQ Maintenance Team

4 Standards and Controls

Validation of all data is conducted by the PDQ Maintenance Team prior to release of each revision. To ensure the database is installed and functioning properly, a "QA/QC test" query is supplied to each user. This query is to be returned to the RCMP prior to expiration of the previous version of the database.

5 Sampling or Sample Selection

Not applicable.

6 Procedure

1. Utilizing Paints and Polymers Standard Operating Procedures (P&P SOPs), determine if a paint sample is a factory-applied, original equipment manufacturer's (OEM) automotive finish.

2. If the sample contains an OEM automotive finish, conduct Fourier transform infrared spectroscopy (FTIR) analysis of the relevant layers utilizing P&P SOP *FTIR Analysis of Paints, Tapes, and Polymers*.

3. Using the IR peak assignment charts in Appendix A as a guide, code the FTIR spectrum of each layer.

4. If sample size permits, elemental analysis can also be conducted to further characterize the paint layers.

5. Code only inorganic information for the primer (undercoat) layer(s).

6. (Optional): Assign Munsell color designations to the primer layer(s). For details, refer to the P&P SOP *Visual, Microscopical, and Microchemical Examination of Paint and Coating Evidence*.

7. Conduct layer system queries through the PDQ database and/or search collected FTIR spectra using the PDQ spectral libraries.

8. Evaluate potential manufacturer candidates using the P&P SOPs *Conducting Color Comparisons Using Automotive Refinishers Color Chips* and/or *Conducting Motor Vehicle Make-Model-Year Searches Using the National Automotive Paint File (NAPF) Database*.

9. Analyze any available archived sample(s) or potential candidates using the appropriate P&P SOP(s) and directly compare the results to the evidentiary paint sample.

7 Decision Criteria

a. For a layer system query search:

   1. Evaluate the candidates acquired. Search criteria can be adjusted to broaden or narrow the search results. FTIR spectra of possible hits can be compared to further evaluate a candidate.

   2. Once the search criteria are established, determine if a particular manufacturer and/or assembly plant is predominant.

b. For a spectral library search:

   1. Compare each spectral candidate to the spectrum in question. If the spectra and color assignment compare favorably , that layer is considered a candidate.

   2. Alternatively, conduct simultaneous multilayer spectral searches in order to target a particular plant more efficiently.

8 Calculations

Not applicable.

9 Measurement Uncertainty

Not applicable.

10 Limitations

a. A factory-applied, OEM automotive finish is required for a possible motor vehicle make-model-year determination.

b. Not all makes and/or years of vehicles produced by each manufacturer are present in the PDQ database.

c. Sample size and condition can preclude conducting certain examinations, including color assessment and layer structure.

11 Precautionary Statement

Some data entry errors have been noted in the PDQ database. Verify search results using orthogonal resources when practicable.

12 Safety

Not applicable.

13 References

ASTM E1610, Standard Guide for Forensic Paint Analysis and Comparison. ASTM International, West Conshohocken, PA

ASTM E2937, Standard Guide for Using Infrared Spectroscopy in Forensic Paint Examinations. ASTM International, West Conshohocken, PA

ASTM E2809 Standard Guide for Using Scanning Electron Microscopy/ X-Ray Spectrometry in Forensic Paint Examinations, ASTM International, West Conshohocken, PA

Beveridge, A., Fung, T., and MacDougall, D. Use of infrared spectroscopy for the characterization of paint fragments. Chapter 10 in *Forensic Examination of Glass and Paint*. (ed. B. Caddy) Taylor and Francis: NY, 2001.

Buckle, J.L., MacDougall, D.A., and Grant, R.R. PDQ- Paint Data Queries: The history and technology behind the development of the Royal Canadian Mounted Police forensic laboratory services automotive paint database *Can. Soc. Forens. Sci. J.*, 1997; 30 (4): 199-212.

Conducting Color Comparisons Using Automotive Refinishers Color Chips, FBI Laboratory, Chemistry Unit - Paints and Polymers SOP

Conducting Motor Vehicle Make-Model-Year Searches Using the National Automotive Paint File (NAPF) Database, FBI Laboratory, Chemistry Unit - Paints and Polymers SOP
FTIR Analysis of Paints, Tapes, and Polymers, FBI Laboratory, Chemistry Unit - Paints and Polymers SOP

Visual, Microscopical, and Microchemical Examinations of Paint and Coating Evidence, FBI Laboratory, Chemistry Unit - Paints and Polymers SOP

MacDougall, D.A. Forensic Analysis of automotive paints at the Royal Canadian Mounted Police *Crime Lab Digest*, 1995; 22(3): 99.

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Scientific Working Group on Materials Analysis (SWGMAT). Forensic Paint Analysis and Comparison Guidelines. *Forensic Science Communications,* 1999; 1(2).

SEM Analysis of Paints, Tapes, and Polymers, FBI Laboratory, Chemistry Unit - Paints and Polymers SOP

The 2007 North American Clearcoat Market Database. Bayer Material Science Market Development Group, Auburn Hills, MI, May 14, 2008.

The 2008 North American Clearcoat Market Database. Bayer Material Science Market Development Group, Auburn Hills, MI, February 8, 2010.

Wright, D.M. A Make-Model-Year Case Involving Unusual Primer Chemistry and Good Resources, *J Amer. Soc. Trace Evid. Examiners*, 2010, 2(2): 137-148.

Wright, D.M. Sourcing Paint Smears: A Hate Crime Highlights the Utility of the Paint Data Query (PDQ) Database. Can. Soc. Forensic Sci. J., 2012, 45(2): 79-88.

Rev. #	Issue Date	History
0	06/21/06	New document that replaces previous document also titled *Conducting Motor Vehicle Make-Model-Year Searches Using the Paint Data Query (PDQ) Databases.*
1	09/30/09	Updated spectral search software options, references, and Appendix.
2	03/14/12	Updated numbers for PDQ in Section 3. Changed macroscopic and microscopic to macroscopical and microscopical throughout document as appropriate. Updated references in section 15.
3	02/03/14	Changes made throughout document to reflect increased capabilities of PDQ software and functionality, new software and hardware requirements, edited Scope to state users should receive hands on training to effectively utilize PDQ, changed “macroscopical” to “visual” throughout, made minor editorial changes, and added reference.
4	09/18/18	Modified scope, deleted “calibration” section, changed section titles as needed to reflect LOM or practice changes, corrections and grammar edits, deleted prescribed SOPs for some analyses to allow for flexibility and updated references.

Approval

Redacted - Signatures on File

Paints and Polymers
Technical Leader: Date: 09/17/2018

Chemistry Unit Chief: Date: 09/17/2018

QA Approval

Quality Manager: Date: 09/17/2018

Appendix A [1]:

Table 10.2 Diagnostic peaks of common binders/resins used in automotive paints

Binder/Resin	Coding	Key peaks (cm^{-1})
Acrylic	ACR	1450 1380 1260 1170 1150
Ortho-phthalic alkyd	ALK OPH	1450 1380 1270* 1130* 1070* 740 700
Isophthalic alkyd	ALK IPH	1475 1373 1305 1237* 1135 1074 730*
Terephthalic alkyd	ALK TER	1270 1250 1120 1105 1020 730
Benzoguanamine	BZG	1590 1540 825 789 710
Cyano	CYA	
Acrylonitrile N≡C	CYA NIT	2238
Isocyanate residue N=C=O	CYA ICN	2272
cf. ferrocyanide, $Fe(CN)_6$		(2092)
Epoxy	EPY	1610 1510* 1240 1180 830*
Melamine	MEL	1550 815
Nitrocellulose	NCL	1650 280 840
Polybutadiene	PBD	970 915
Polyurethane	PUR	1690 1530 1470 1250 1070
single peak		1690
modified epoxy		1730 1510 (non-asymmetric broadening)
water based		1690 770
Styrene	STY	1490 1450 760 700
Urea	REA	1655

[1] Reproduction of Table 10.2 in Beveridge, A, et al. Use of Infrared Spectroscopy for the Characterization of Paint Fragments. Chapter 10 in *Forensic Examination of Glass and Paint* (ed. B. Caddy) Taylor and Francis: NY, 2001.
* indicates a major peak

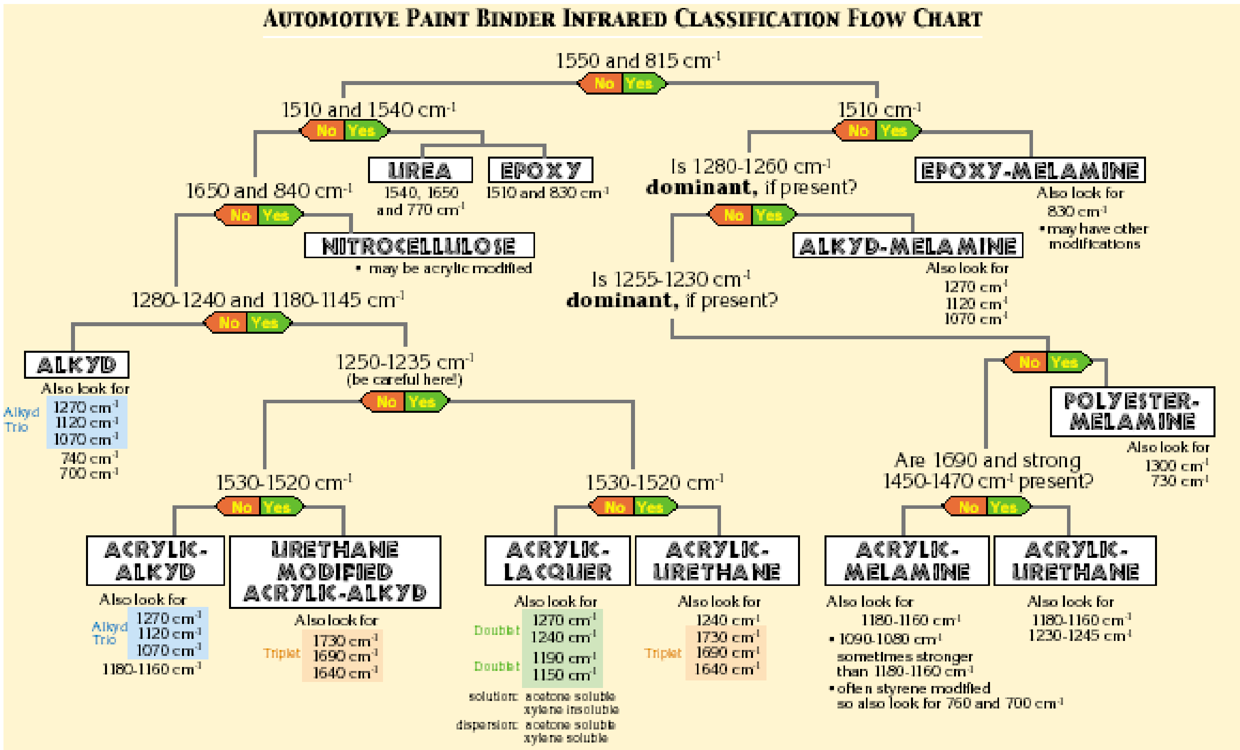
Appendix A (continued)[2]:

Table 10.3 Diagnostic peaks of common pigments and extenders used in automotive paints

Pigment and extender	Coding	Key peaks (cm^{-1})
Calcium carbonate	CAR CAC	
Aragonite	CAR CAC ARA	1445 870 857 712 317
Calcite	CAR CAC CAL	1445 870 712 317
Chromate	CHR	
Barium chromate	CHR BCH	935 896 860
Potassium zinc chromate	CHR KZC	950 880 805
Strontium chromate	CHR SCH	920 885 860 840
Oxide	OXI	
Iron oxide	OXI FEO RED	560–530 480–440 350–310
Iron oxide	OXI FEO YEL	899 797 606 405 278
Lead oxide	OXI PBO	530 450
Zinc oxide	OXI ZNO	420–500
Silicon dioxide	OXI SIO	
Cristobalite	OXI SIO CRI	1090 795 621 485 387 300
Opal, diatomaceous silica	OXI SIO OPA	1099 795 475
Quartz	OXI SIO QUA	1081 798 779 512 460 397 373
Titanium dioxide	OXI TIO	
Rutile	OXI TIO RUT	600 (broad suppression) 410 340
Anatase	OXI TIO ANA	600 (broad suppression) 340
Zinc phosphate	PHO ZNP	1120 1080 1020 950 630
Silicate	SIL	
Magnesium (talc)	SIL MGS TAL	1015 670 465 450 420 390 345
Aluminium (kaolinite)	SIL ALS KAO	1035 1005 940 910 540 470 430 350 280
Barium sulphate	SUL BAS	980 630 610

[2] Reproduction of Table 10.3 in Beveridge, A., et al. Use of Infrared Spectroscopy for the Characterization of Paint Fragments. Chapter 10 in *Forensic Examination of Glass and Paint* (ed. B. Caddy) Taylor and Francis: NY, 2001.

Appendix A (continued)[3]:



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[3] Courtesy of Scott Ryland (retired), Florida Department of Law Enforcement, from Course entitled "Paint Examination and Comparison"