RDT&E IWG Paint and Other Coatings Questions

1. *What is the literature on the transfer and retention of paints and coatings evidence?*
   Buzzini, P., Massonnet, G., Birrer, S., Egli, N.M., Mazzella, W., Fortini, A. (2005). Survey of crowbar and household paints in burglary cases-population studies, transfer and interpretation. *Forensic Science International, 152(2-3),* 221-234.

   Individual, successive, and cross-transfer simulations, totaling 198 such scenarios, were carried out between crowbars and painted wood substrates in order to study the phenomenon of transfer as well as evaluate the amount of paint transferred. Chemical composition and age of the paint influenced the amount of observed transfer with bidirectional cross-transfer between the wood and tool regularly observed. Secondary paint transfers from the substrate were also regularly observed.

   Lau, L., Beveridge, A.D., Callowhill, B.C., Conners, N., Foster, K., Groves, R.J., et. al. (1997). The frequency of occurrence of paint and glass on the clothing of high school students. *Canadian Society of Forensic Science Journal, 30(4),* 233-240.

   A frequency of occurrence study of paint chips observed on the outer clothing and footwear of 213 high school students from different areas of the Vancouver, British Columbia, Canada was conducted, in which paint was found on approximately 14% of the outer clothing items, and on approximately 24% of footwear. The authors noted that the percentages were significantly lower than figures reported in similar studies in the previous 25 years.

   McDermott, S.D., Willis, S.M. (1997) A survey of the evidential value of paint transfer evidence. *Journal of Forensic Sciences, 42(6),* 1012-1018.

   A questionnaire regarding the evidential value of paint transfer in 8 traffic accident cases was distributed to 235 paint examiners working in crime laboratories. 124 replies were received with conclusions ranging from "slight support" to "conclusive" allowed.

   Pearson, E.F., May, R.W., Dabbs, M.D.G. (1971) Glass and paint fragments found in men's outer clothing – a report of a survey. *Journal of Forensic Sciences, 16(3),* 283-302.

   Over the course of three months, 100 pairs of men's jackets and trousers were chosen at random from a dry cleaning business and examined for the presence of glass and paint transfer. When fragments of identical color and layer structure were grouped together, 1077 paint samples were counted.

   Marsh, L. (2009) What's on the Highway? Frequency of Occurrence of Paint Chips Amongst Debris Collected from Road Surfaces
   http://projects.nfstc.org/trace/2009/presentations/7-marsh-highway.pdf

This study posed several questions:

How common is the presence of random automotive paint chips on a person's clothing?

100 garments were shaken with surface debris collected and examined at ~25X magnification. When all paint chips were counted, 95/100 garments contained paint for a total number of 1,253 paint chips divided into 1,008 different populations. Of these, 9% contained 2 layers and 1% contained 3+ layers; none of the recovered paint chips were automotive.

How common are random automotive paint chips on the road?

Results indicated paint chips ranging in size from 100-2200 microns were found in 20/27 (74%) of samples, for a total of 191 paint chips in 113 different populations. Further, 41 paint chips contained more than 2 paint layers (21%); only 3 were automotive paint chips, which were observed in two samples. Therefore, the 'chance' of finding car paint chips in this sample population was 2/27 (e.g., 7%).

If car paint chips are found on the victim's clothing, how significant is this finding?

From a high chance (+74%) that paint chips are present on the road, only 7% were car paint chips.

Therefore, the finding of car paint chips on a person's clothing at random is very unlikely since it was rare to find random automotive paint chips from the road transferred to clothing in this investigation (0/ 1,253 paint chips were car paint)

2. *What literature describes the quantitative and qualitative optical, morphologic/structural, physical or chemical properties and features, useful for layered component and whole sample paints and coatings examinations?*

The list is extensive; examples of some of the more relevant articles follow.

Adamsons, K. (2002). Chemical Depth Profiling of Multi-Layer Automotive Coating Systems. *Progress in Organic Coatings 45:2/3*, 69-81.

ASTM E1610-02 (2008), Standard Guide for Forensic Paint Analysis and Comparison. ASTM International, West Conshohocken, PA.

Audette, R.J. and Percy, R.F.E. (1979). A Rapid, Systematic, and Comprehensive Classification System for the Identification and Comparison of Motor Vehicle Paint Samples I: The Nature and Scope of the Classification System. *Journal of Forensic Sciences, 24(4)*, 790-807.

Audette, R.J. and Percy, R.F.E. (1980) Automotive Repaints: Just a New Look? *Journal of Forensic Sciences, 25(1)*, 189-239.

Beattie, B., Dudley, R.J. Smalldon, K.W. (1979). The Use of Morin Staining for the Microscopic Characterization of Multilayered White Paint Flakes. *Forensic Science International, 13 (1)*, 41-49.

Boudreau, A.J. Cortner, G.V. (1979). Application of Differential Interference Contrast Microscopy to the Examination of Paints. *Journal of Forensic Sciences, 24 (1)*, 148-153.

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Cartwright, L.J., Cartwright, N.S., Norman, E.W.W., Cameron, R., MacDougall, D.A. (1984). The Classification of Automotive Paint Primers Using the Munsell Color Coordinate System - A Collaborative Study. *Canadian Society of Forensic Science Journal, 17(1)*, 14-18.

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Flynn, K., O'Leary, R., Lennard, C., Roux, C., Reedy, B. (2005). Forensic Applications of Infrared Chemical Imaging: Multi-layered Paint Chips. *Journal of Forensic Sciences, 50 (4)*, 832-841.

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Hudson, G.D., Andahl, R.O., Butcher, S.J. (1977). The Paint Index - The Colour Classification and Use of a Collection of Paint Samples Taken from Scenes of Crime. *Journal of the Forensic Science Society, 17*, 27-32.

Kilbourn, J.H., Marx, R. B. (1994). Polarized Light Microscopy of Extenders in Structural Paints - Forensic Applications. *The Microscope, 42(4)*, 167-175.

Kirk, P.L. (1985). Paint. Crime Investigation, Second Edition, J.I. Thornton, ed. Malabar, Florida: Robert Krieger Publishing Company, Inc.

Laing, D.K. (1990). Paint Examination Using Thin Sections. *Forensic Science International 46*, 37-39.

Learner, T.J.S. (2004). Analysis of Modern Paints, Research in Conservation Series, The Getty Conservation Institute, Los Angeles, CA:Getty Publications.

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McCrone, W.C. (1979). Application of Particle Study in Art and Archaeology Conservation and Authentication. The Particle Atlas, Vol. V, 2nd Ed., McCrone, W.C., Delly, J.G. and Palenik, S.J., Ann Arbor, MI: Ann Arbor Science Publishers, Inc.

McCrone, W.C. (1979). Particle Analysis in the Crime Laboratory. The Particle Atlas, Vol. V, 2nd Ed., McCrone, W.C., Delly, J.G. and Palenik, S.J. (Eds.). Ann Arbor, MI: Ann Arbor Science Publishers.

McCrone, W.C. (1985). The Microscopical Identification of Artists' Pigments. *Journal of the International Institute of Conservation-Canadian Group, 7 (1)*, 11-34.
Moenssens, A.A., Inbau, F.E., and Starrs, J.E. (1986). Scientific Evidence in Criminal Cases. NY: The Foundation Press, Inc.

Morgans, W.M. (1990). Outlines of Paint Technology, 3rd edition. NY: Halsted Press.

New Special Effects Almost "Mystical". (1996). *Industrial Paint and Powder*, 22.

Nielsen, H.K.R. (1984). Forensic Analysis of Coatings. *Journal of Coatings Technology, 56 (718)*: 21-32.

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Ryland, S. (2010). Discrimination of Retail Black Spray Paints. *Journal of the American Society of Trace Evidence Examiners, 1(2)*, 109-126.

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Stoney, D.A. Zona, C., Cai, X. (1991). Identification of Paint Pigment Sublimates by Optical Crystallography. Proceedings of the International Symposium on the Forensic Aspects of Trace Evidence, U.S. Government Printing Office, ISBN 0-932115-12-8.

Thornton, J.I. (1982). Forensic Paint Examination. Forensic Science Handbook, Vol. I. , Saferstein, R., ed., Englewood Cliffs, NJ: Prentice-Hall, Inc.

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Wilkinson, J.M., Rickard, R.A., Locke, J., and Laing, D.K. (1987). The Examination of Paint Films and Fibers as Thin Sections *The Microscope, 35 (3)*, 233-248.

Wright, D.M., Bradley, M.J., Mehltretter, A.H. (2011). Analysis and discrimination of architectural paint samples via a population study. *Forensic Science International, 209,* 86-95.

3. *What is the literature on the classification of paints and coatings and their component pigments, binders, and vehicles?*

The list is extensive; examples of some of the more relevant articles follow.

Additives Guide. *Paint and Coatings Industry*, published yearly. www.pcimag.com. BNP Media, Inc. Skokie. IL.

ASTM D4764-01 (2006), Standard Test Method for Determination by X-Ray Fluorescence Spectroscopy of Titanium Dioxide Content in Paint. ASTM International, West Conshohocken, PA.

ASTM D5380-93 (2003), Standard Test Method for Identification of Crystalline Pigments and Extenders in Paint by X-Ray Diffraction Analysis. ASTM International, West Conshohocken, PA.

ASTM D5381-93 (2003). Standard Guide for X-Ray Fluorescence (XRF) Spectroscopy of Pigments and Extenders. ASTM International, West Conshohocken, PA.

***Automotive Paints and Coatings* (1995). G. Fettis, ed., NY:VCH Publishers.**

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Becidyan, N. (June 2003). The Chemistry and Physics of Special-Effect Pigments and Colorants for Inks and Coatings. *Paint and Coatings Industry*, www.pcimag.com. BNP Media, Inc. Skokie. IL., 66-76.

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The Chemistry and Physics of Coatings, 2nd edition. (2004). A.R. Marrion, ed. Cambridge: Royal Society of Chemistry.

Gutoff, E.B., and Cohen, E.D. (2006). Coating and Drying Defects: Troubleshooting Operating Problems, 2nd edition. Hoboken, NJ: John Wiley and Sons, Inc.

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Helstroffer, S., Espanet, B., Milet, S. (2003). Class Identification of Rocket Types by Paint Analysis: A New Way. *Forensic Science International, 136(1),* 353-354.

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Skanden, G., et al. (November 1999). Production of Nanpowders by Chemical Vapor. *Vacuum and Thin Film, 2(11),* 28-33.

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Wicks, Z.W., Jr., Jones, F.N., Pappas, P., and Wicks, D.A. (2007). Organic Coatings: Science and Technology, 3rd edition, Hoboken, NJ: John Wiley and Sons, Inc.

Wilkinson, J.M., Locke, J., and Laing, D.K. (1988). The Examination of Paints as Thin Sections using Visible Microspectrophotometry and Fourier Transform Infrared Microscopy. *Forensic Science International, 38,* 43-52.

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Zeichner, A. et al. (1992). A Study of Paint Coat Characteristics Produced by Spray Paints form Shaken and Nonshaken Spray Cans. *Journal of Forensic Sciences, 37(2),* 542-555.

4. What is the literature on the variation of paints and coatings?

   The list is extensive; examples of some of the more relevant articles follow.

Bentley, J. (2001). Composition, Manufacture, and Use of Paint. ***Forensic Examination of Glass and Paint: Analysis and Interpretation.*** **B. Caddy, ed. London: Taylor and Francis.**

Bleile, H.R., and Rodgers, S. (1989). Marine Coatings. ***Federation Series on Coatings Technology,*** **Federation of Societies for Coatings Technology, Blue Bell, PA.**

Brandau, A. (1990) Introduction to Coatings Technology. ***Federation Series on Coatings Technology,*** **Federation of Societies for Coatings Technology, Blue Bell, PA.**

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Laing, D.K., et al (1982). The Discrimination of Small Fragments of Household Gloss Paint by Microspectrophometry. ***Forensic Science International, 20,*** **191- 200.**

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Triplett, T. (April 1996). Lab Tests: Where the Finish Starts. *Industrial Paint and Powder,* 34-37.

Zeichner, A. et al. (1992). A Study of Paint Coat Characteristics Produced by Spray Paints from Shaken and Non-shaken Spray Cans. *Journal of Forensic Sciences, 37(2),* 542-555.

5. What is the literature on the persistence of paints and coatings evidence, including the effects of weathering (e.g. sunlight, humidity, temperature, etc.), aging (e.g. oxidation, etc.), post washing and waxing effects, and how it affects the conclusions of paints and coatings analysis?

   The list is extensive; examples of some of the more relevant articles follow.

   Bleile, H.R., and Rodgers, S. (1989). Marine Coatings. *Federation Series on Coatings Technology*, Federation of Societies for Coatings Technology, Blue Bell, PA.

   Cousins, D.R., Platoni, C.R. and Russell, L.W. (1984). The Variation in the Colour of Paint on Individual Vehicles. *Forensic Science International, 24,* 197-208.

   Farkas, F.K. (1999). The Industrial Paint-Making Process. Paint and Surface Coatings, Theory and Practice. R. Lambourne, and T.A. Strivens, eds., Burlington, MA: William Andrew Publishing.

   Gaiski, S.N. (2009). Making it Right: Why Your Car Payments are Lasting Longer than Your Factory Paint Job. TES Editorial Services, ed., Novi, MI: Zestar Corp.

   The book explains paint processing and potential causes for defects in laymens terms.

   Parks, D.W., and Jacobs, D.H., Jr. (2003). How to Paint Your Car. Motorbooks Workshop. Minneapolis, MN: MBI Publishing Company.

   Describes in laymen's terms OEM finishes, layer systems, and do-it-yourself (DIY) concepts for refinishing.

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18. What databases are most needed in the field of paints and coatings analysis? (**Note**- this does not require a list of references, it is for informational purposes only.)

The existing PDQ Automotive Paint database is in need of increased consistent funding and support. The database is quite extensive and one of the most valuable tools to forensic paint examiners. Currently, it is a sixteen-year collaborative effort between local, state, and federal US law enforcement agencies and the Royal Canadian Mounted Police (developer of the platform) and has grown into an international database incorporating data from Europe, Asia, and Australia, all of whom participate in the program. The database requires a steady supply of samples in the ever-changing automotive paint market, and skilled analysts are required to ensure the quality of the data. Without additional funding and support, the forensic paint community could lose an extremely valuable resource.

A *comprehensive* current digital collection of infrared spectra of automotive refinish products on the market.

A *comprehensive* digital library of paint coloring and extender pigment Raman spectra.

A *comprehensive* digital library of paint coloring and extender pigment FTIR spectra.

19. What new technologies and areas of research should be pursued with regard to paints and coatings examination and analysis—and in what priority? (**Note**- this does not require a list of references, it is for informational purposes only.)

Aftermarket automotive refinish database: Create an aftermarket automotive paint refinish IR database to characterize current formulations and determine the ability to discriminate an aftermarket refinish from original equipment manufacturer (OEM) paint.

Architectural paint: Studies are needed to evaluate the homogeneity of architectural paints as applied in real-world settings under real-world conditions. Architectural paints could vary due to potential variations in the mixing and application technique(s) of the paint to a substrate. This study would begin to address what constitutes a significant difference between samples.

Error rates: Studies are needed to define and measure error rates with respect to false exclusions and an individual analyst's competency in interpretation.

Error rates: Studies are needed to determine the discrimination potential of specific instruments or techniques comparing statistical models (e.g., PCA) to analysts' interpretations.

Error rates: Studies are needed to look at the rate of false inclusions and exclusions based on analytical regimes utilized (e.g. FTIR only, microscopy only, combinations of techniques).

Emerging techniques: Determine the cost-benefit analysis and discrimination potential (to include factors such as sample size, sample condition) of emerging techniques for paint analysis (e.g., DART, DSC, Cathodoluminescence, LIBS) that will enhance the analytical scheme and/or replace existing traditional techniques (e.g., PGC/Py-GC/MS, SEM-EDS).

Determine the frequency of factory (OEM) refinishes as to how often and how many layers.