Discrimination of Architectural Paints

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Previous work

- Most recent study published on discrimination of architectural paints was Tippett, et al. *J.For.Sci.Soc.*, 8(1968), 61-65.
  - Studied 2000 architectural paint samples using
    - Microscopic examination (layer structure/color)
    - Microchemical tests (solubility testing of binder system)
  - Combination of micro techniques provided 1 in 250,000 chance of a random pair association
    - Emission spectrography (inorganic constituents)
    - Pyrolysis gas chromatography (organic constituents)
  - Provided 1 in 10^6 chance of a random pair association

Purpose of this study

- Update Tippet's research to assess more current paint formulations
- Determine if discriminating power improves with advanced analytical capabilities
- Attempt to address the significance of associations
- Translate significance assessments into language that will provide clearer, more "stand alone" reports as recommended in the recent NAS study on forensic science

Samples

- Collected by FBI field and lab personnel, as well as colleagues at other forensic laboratories in North America
- Over 950 samples submitted
- Collected from interiors and exteriors of residences, businesses, and other public places (restaurants, parks, etc.)

FBI Laboratory Architectural Paint Collection Form

Name of person collecting sample _____

Sample color _____

Address of sampling location (street, city, state, country)

_____

_____

_____

Building type (e.g. house, apartment, business, industrial site) _____

Substrate type (e.g. windowsill, wall) _____

Environmental location (e.g. interior, exterior, direct sunlight) _____

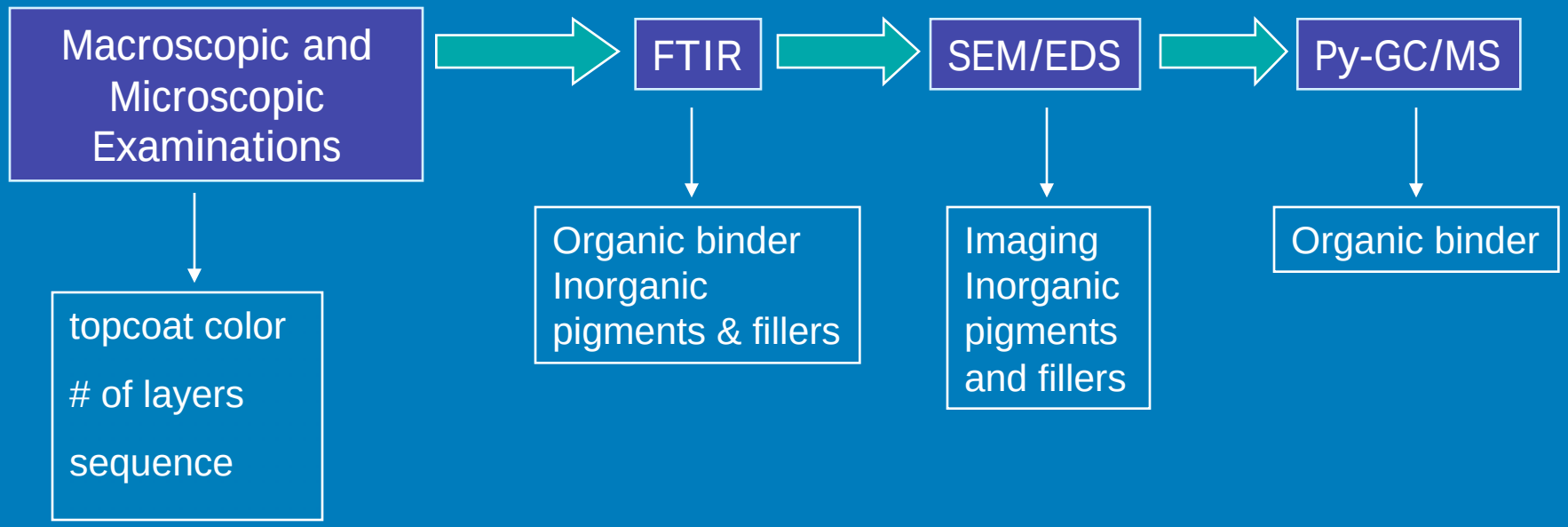
Manufacturer (if known) _____

Approximate age of structure _____

Date of most recent paint application _____

Number of coats applied_____

Analytical Scheme

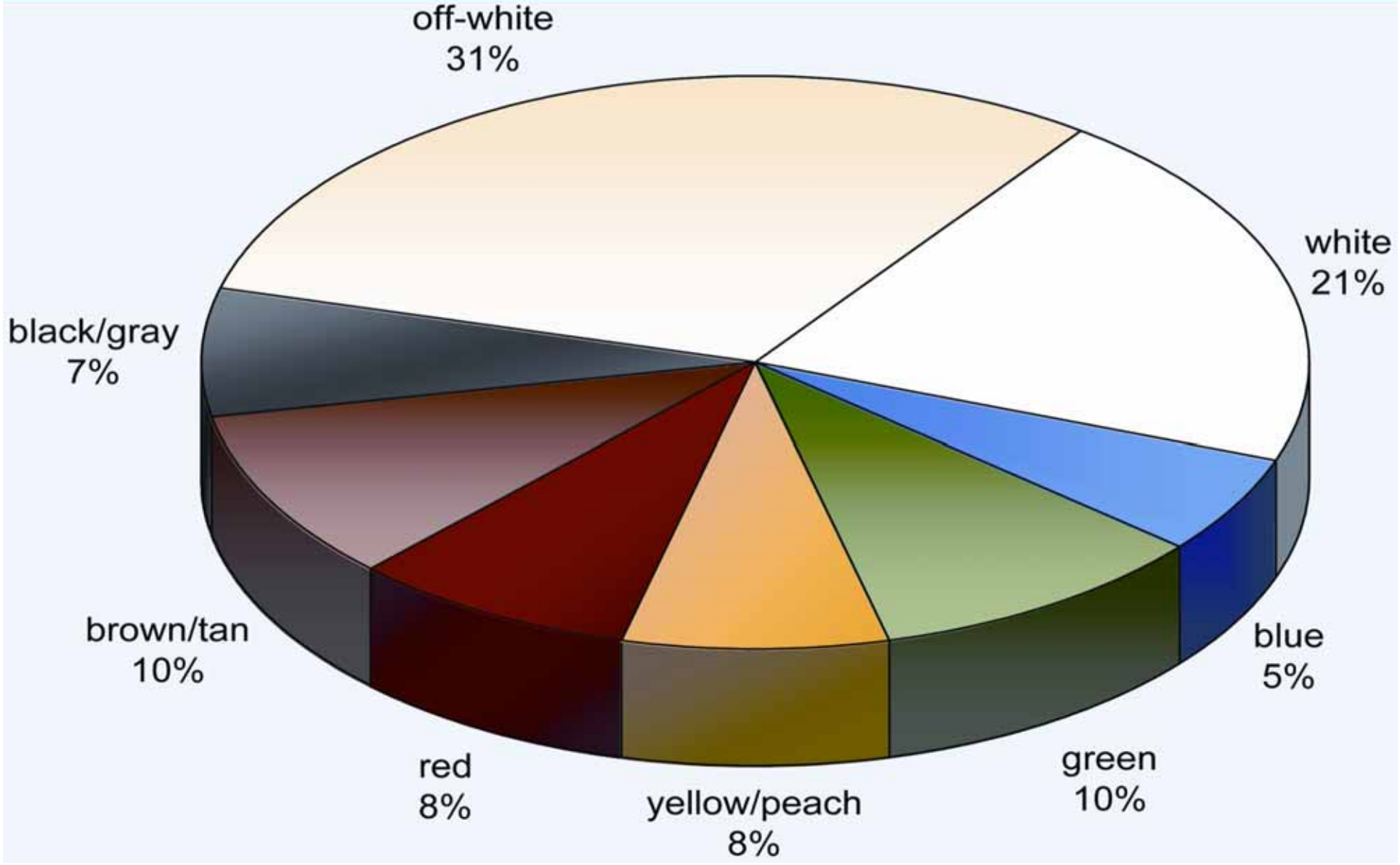


Initial Evaluation of Submissions

Samples were divided into groups by topcoat color (blue, red, brown, etc.)

- ~ 200 classified as “white”
- Remainder possessed some hue
  - Largest group: “off-white” (~300 samples)

Visual Color Categories



Examples of paints in each color category

Macro and Microscopic Exams

- Each sample was initially examined and assessed (e.g. paint or not paint)
  - 15 “not paint” samples observed
- **960 samples intercompared (460,320 pairwise comparisons)**
- If paint, layer structure was determined:
  - Sequence of layers
  - Color and relative thickness of each layer
  - Features such as air voids or delamination
  - Substrates were recorded, but not factored into assessments

Pair-wise comparisons

Samples were compared in more than one color classification as needed.

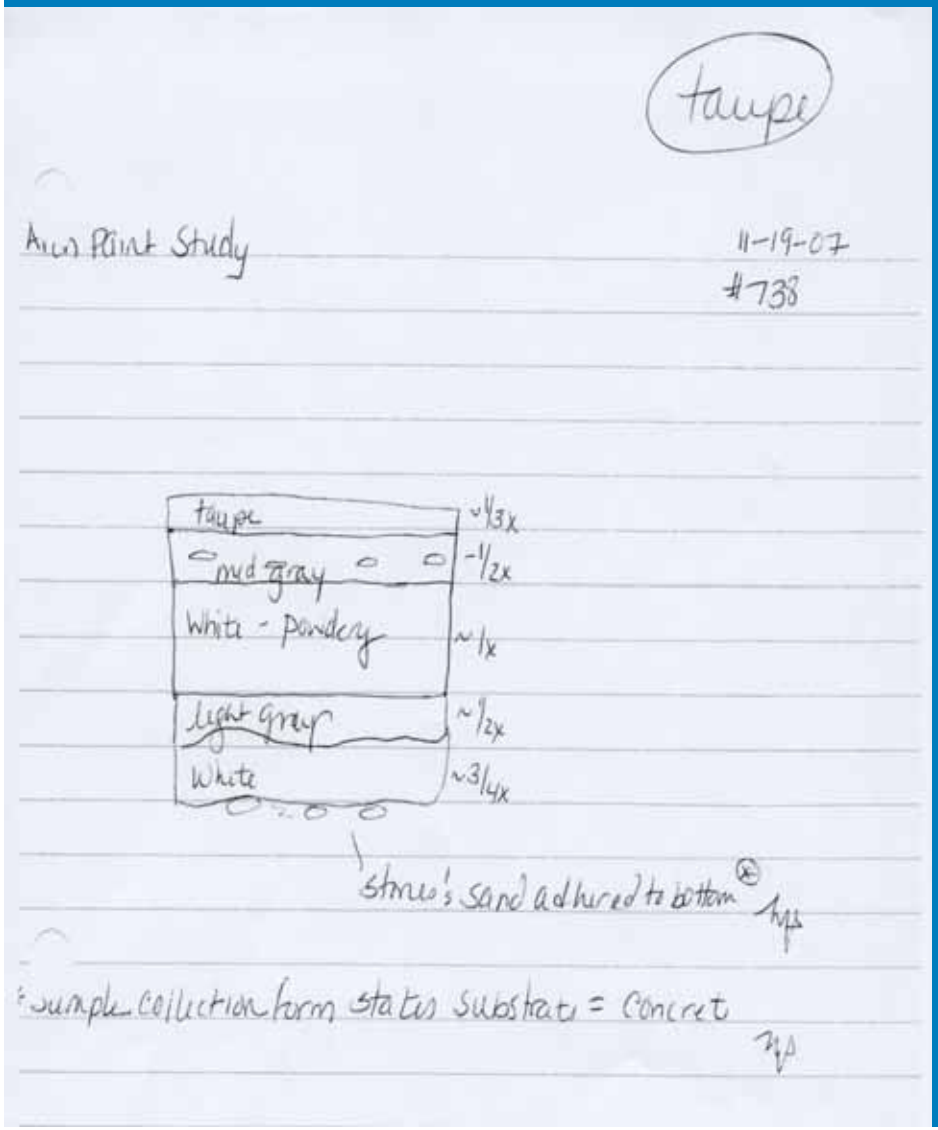
Red

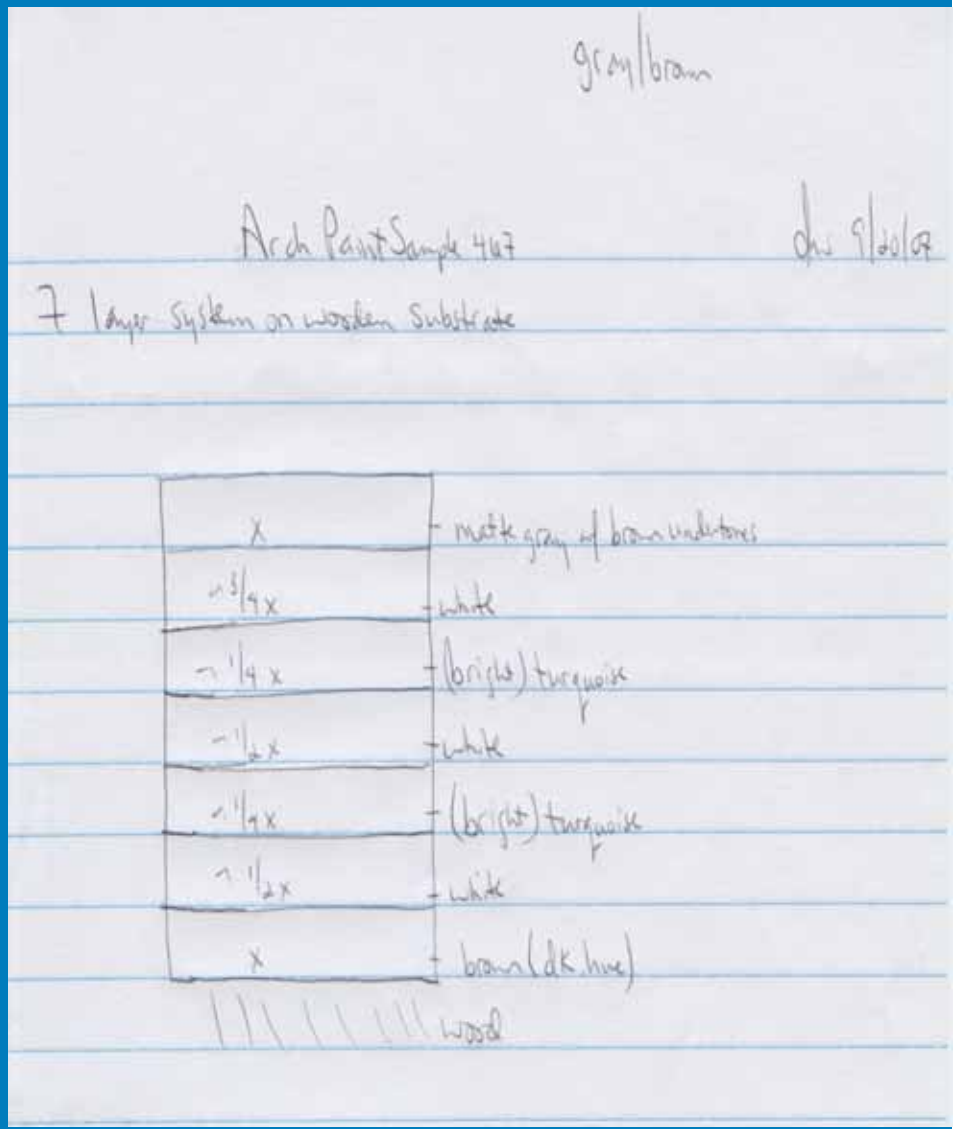
Red-brown

Brick

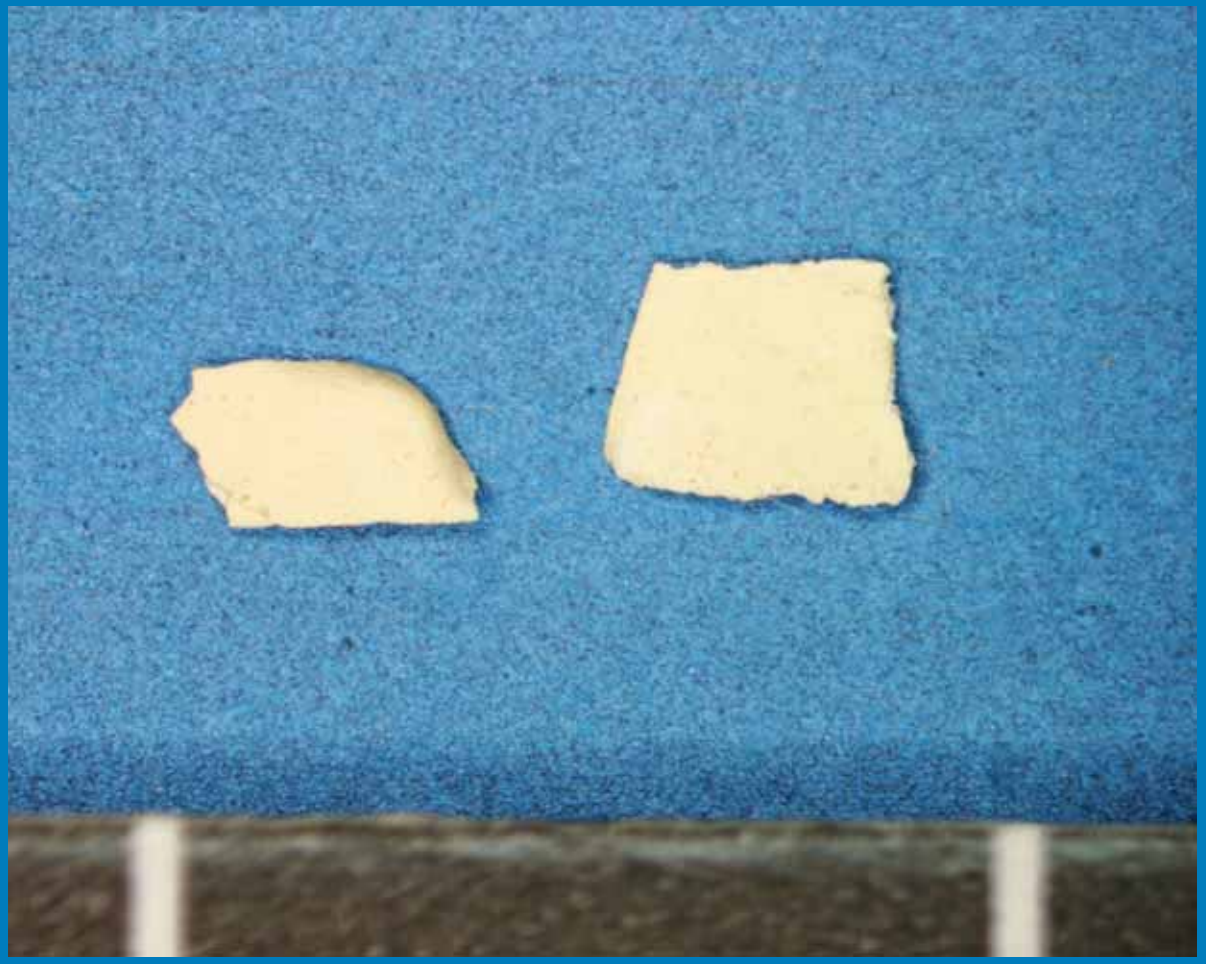
Pair-wise comparisons

Visual/micro notes



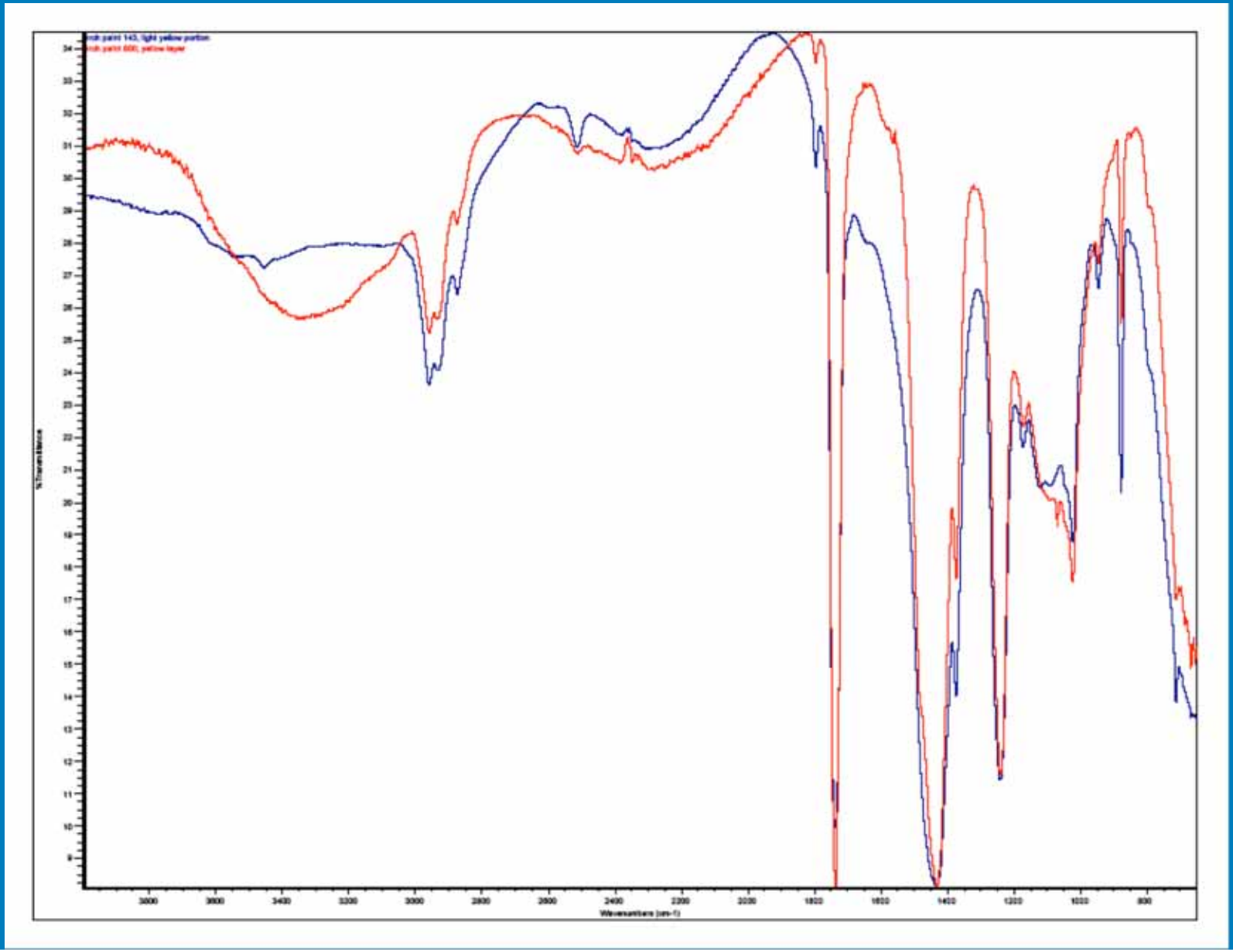


Pair-wise comparisons

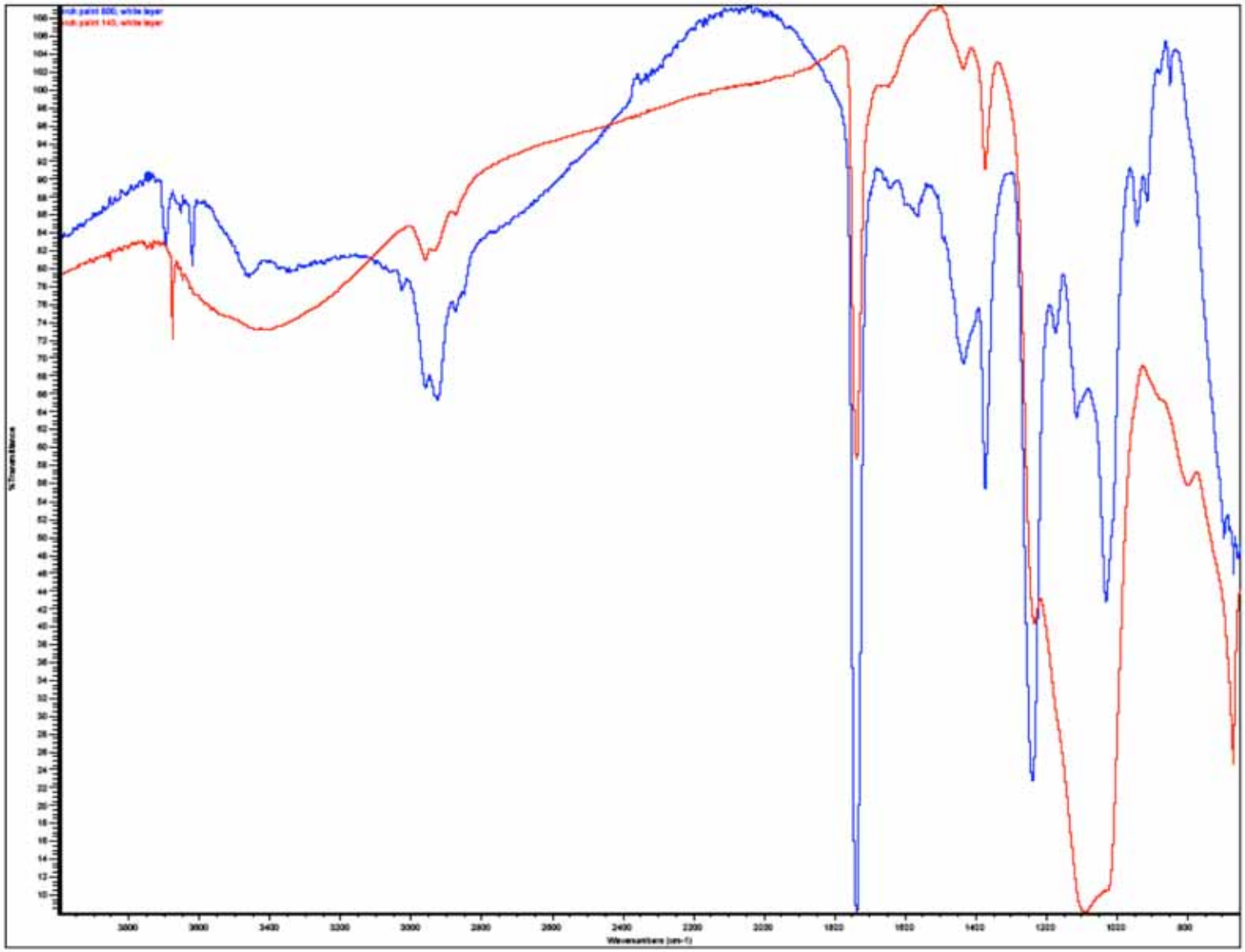


Cross-section of a “like” pair

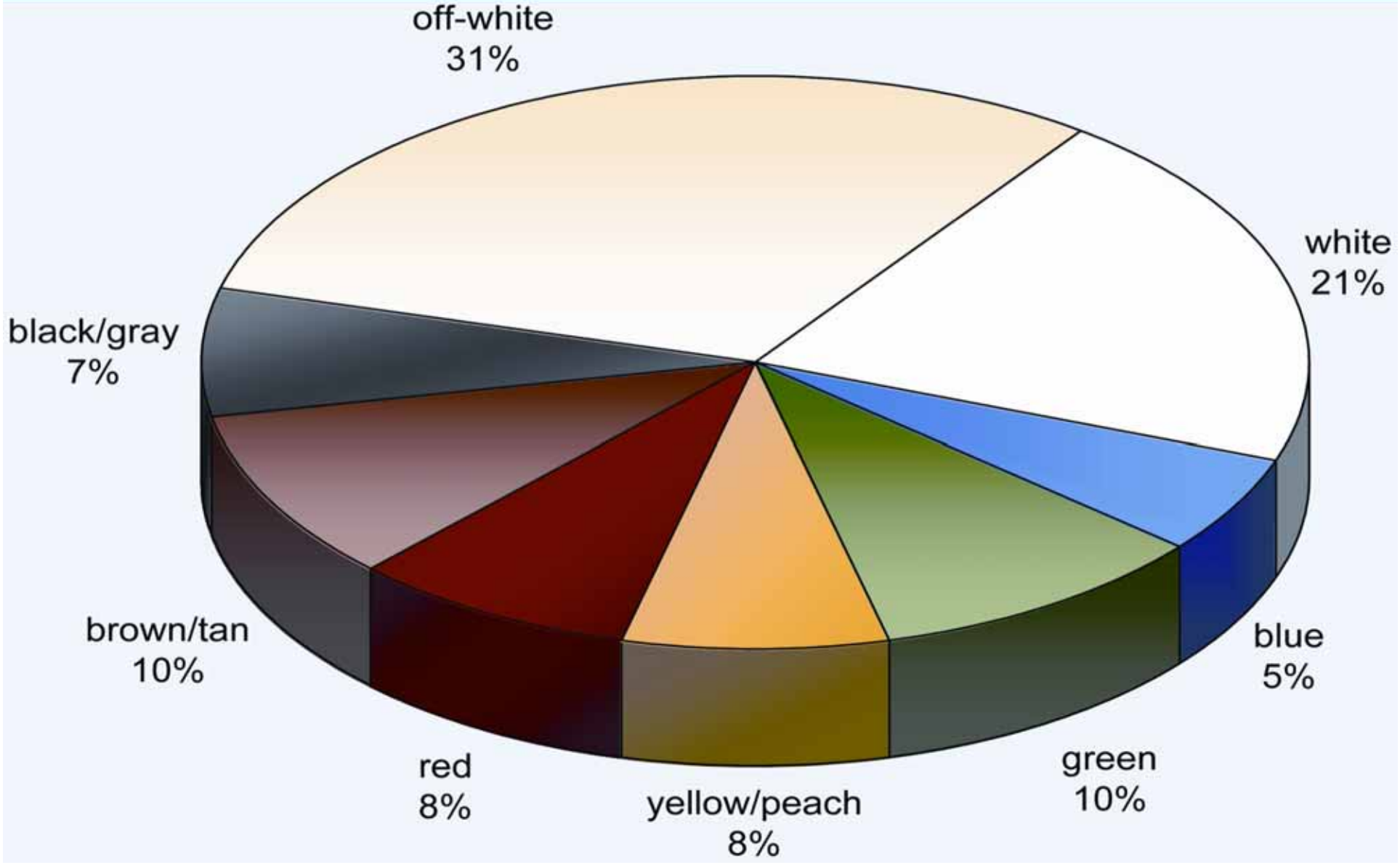
FTIR comparison of topmost (yellow) layer



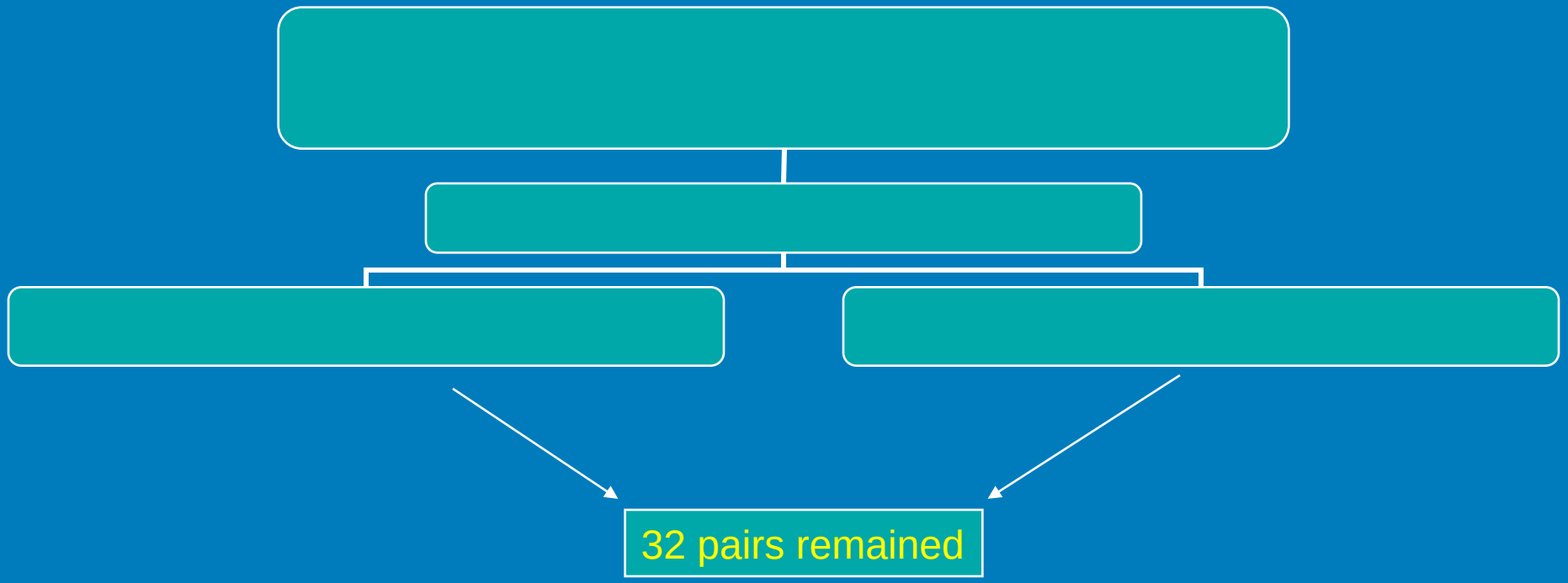
FTIR comparison of bottom (white) layer



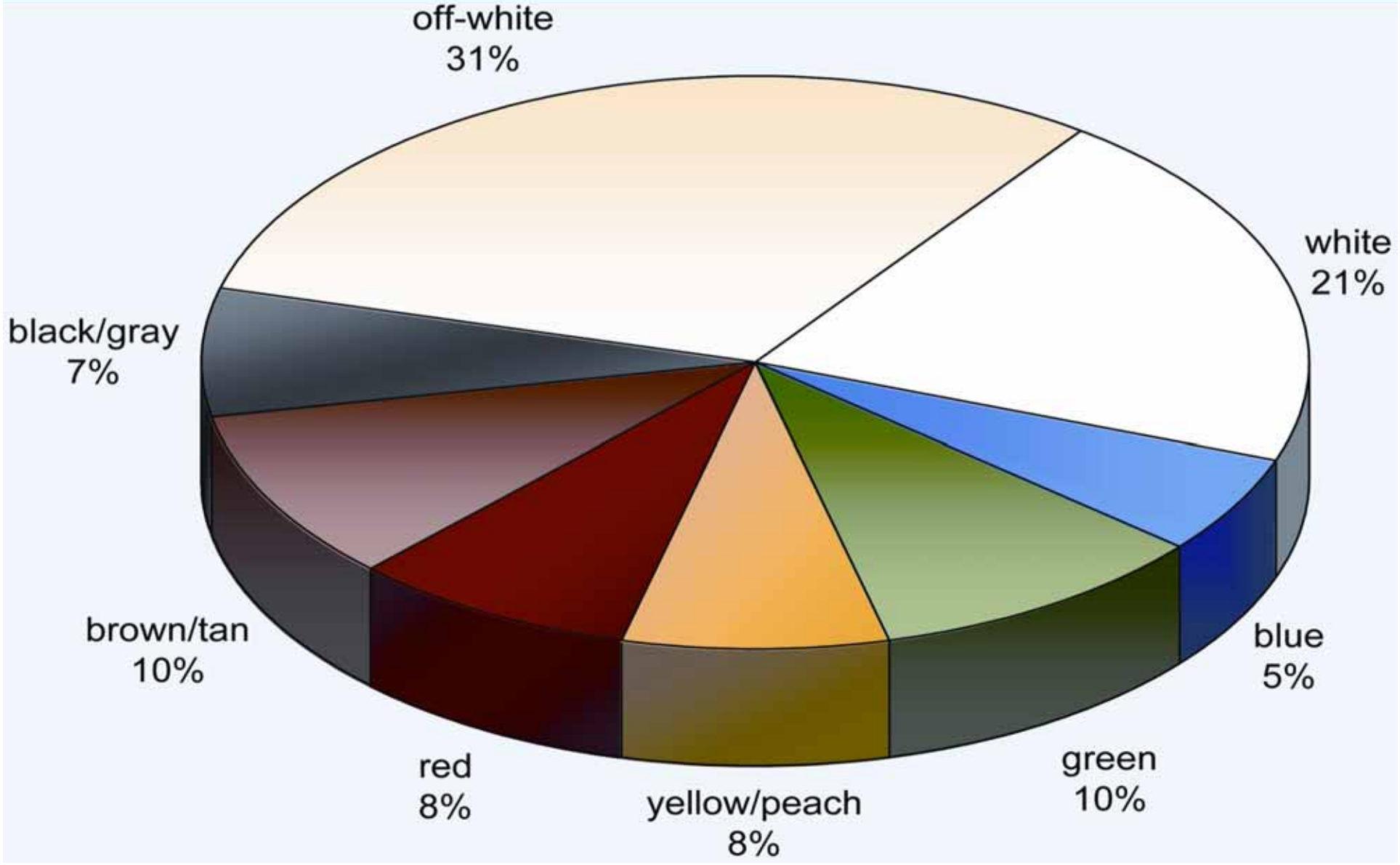
Visual Color Categories



Hued Paint Discrimination:
Physical and FTIR assessments



Visual Color Categories



White Paint Discrimination:
Physical and FTIR assessments

- 197 “white” samples (19,306 pairs)
- 5+ layers - assessed via analyst notes of the physical characteristics
  - None of these 77 samples were comparable.

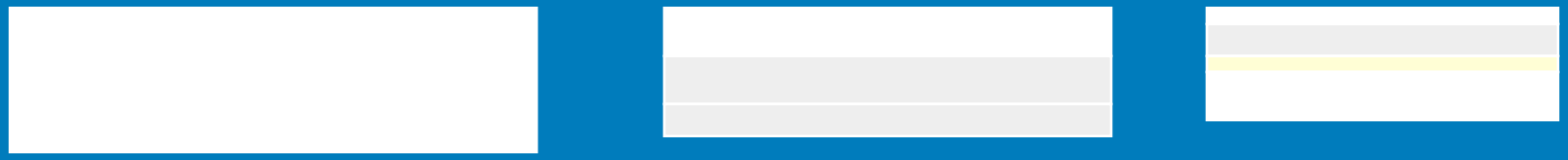
White Paint Discrimination: Summary of Physical and FTIR assessments

- Remaining samples grouped as*:
  - 1 layer ⟶ 69
  - 2 layers ⟶ 47
  - 3+ layers ⟶ 36

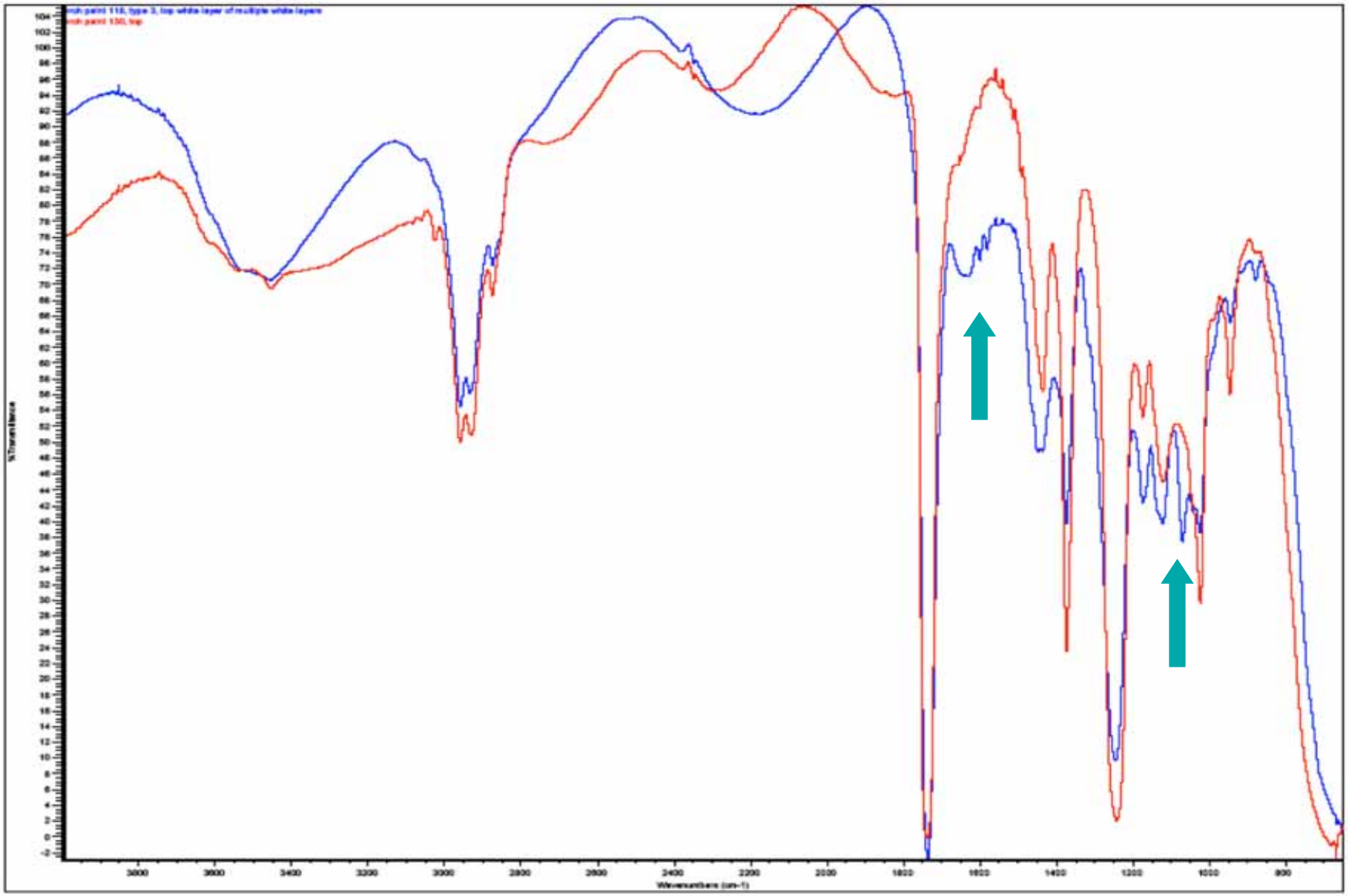
*** Some samples assessed in more than one category**

- Topcoat of each analyzed by FTIR prior to microscopic comparisons.

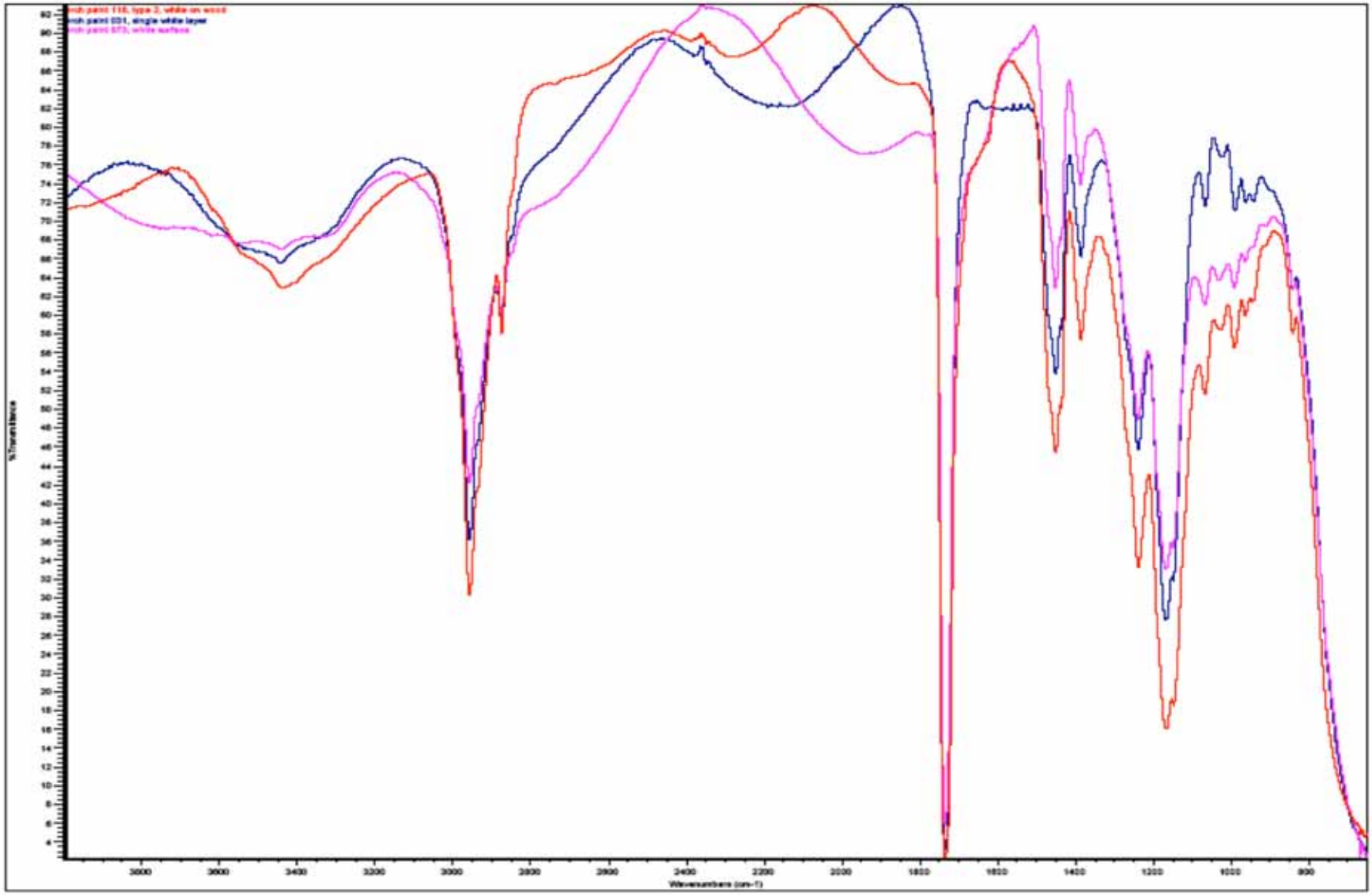
Example of white paint comparison



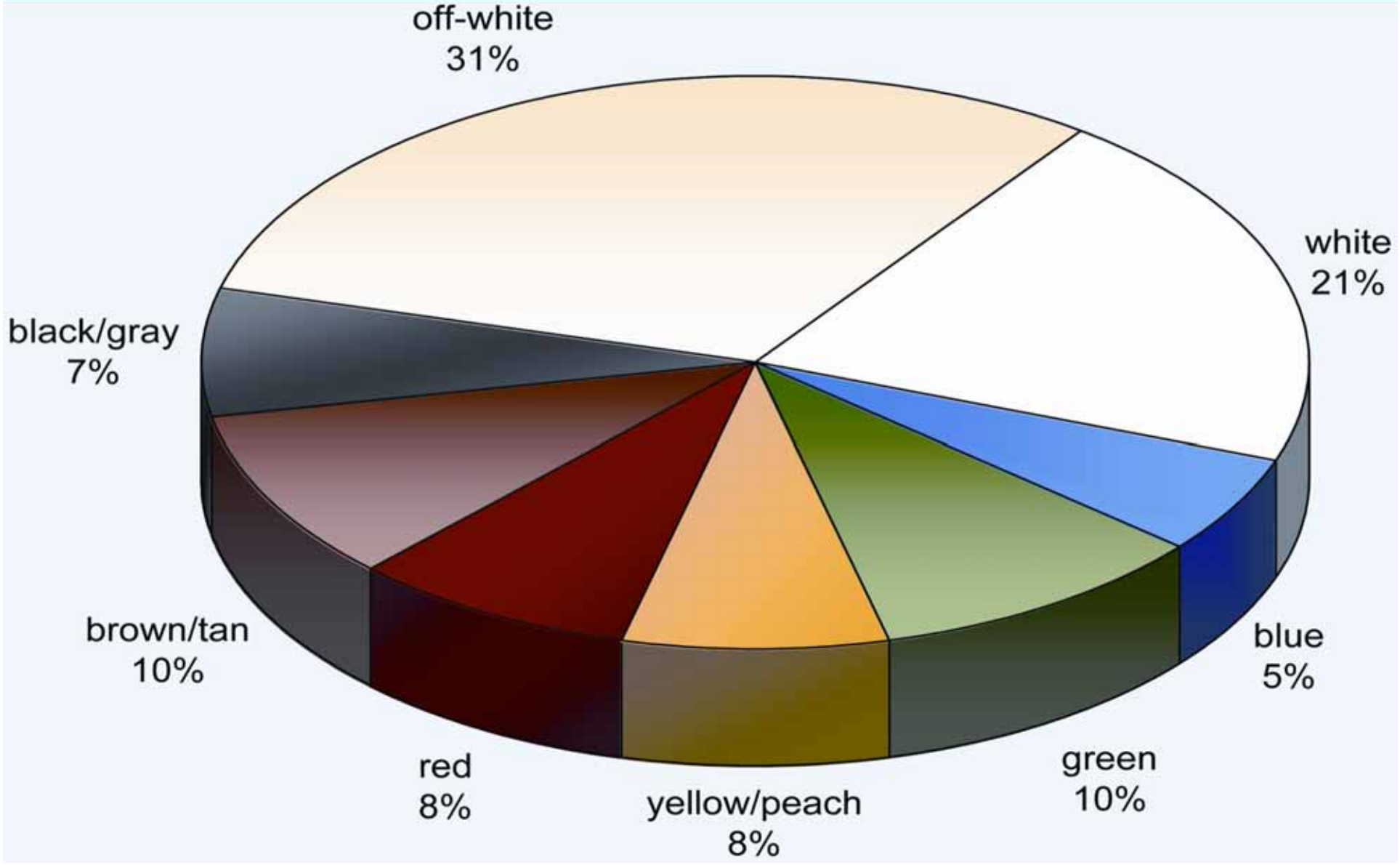
Discrimination of topcoat by FTIR



Comparable FTIR of topcoats



Visual Color Categories



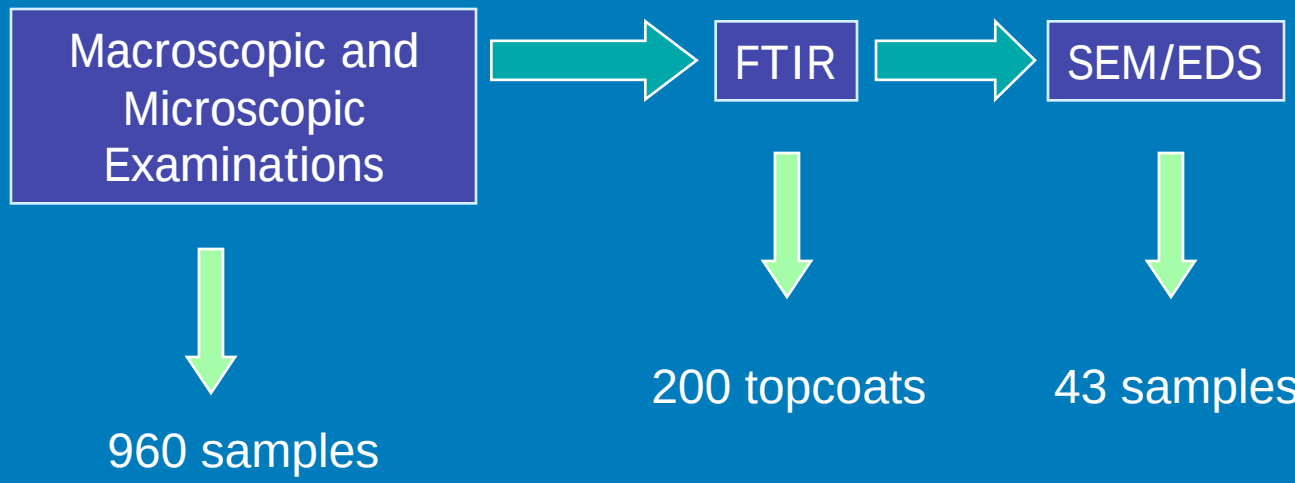
White vs. Off-White Paint Discrimination:
Physical and FTIR assessments

- 54 previously analyzed “hued” samples were directly compared to the “whites”

- Many visually consistent:
  - FTIR conducted on top layer, yielded 12 pairs requiring further assessment.
  - Further microscopic exams discriminated 6 pairs.
  - FTIR of additional layers discriminated one pair.

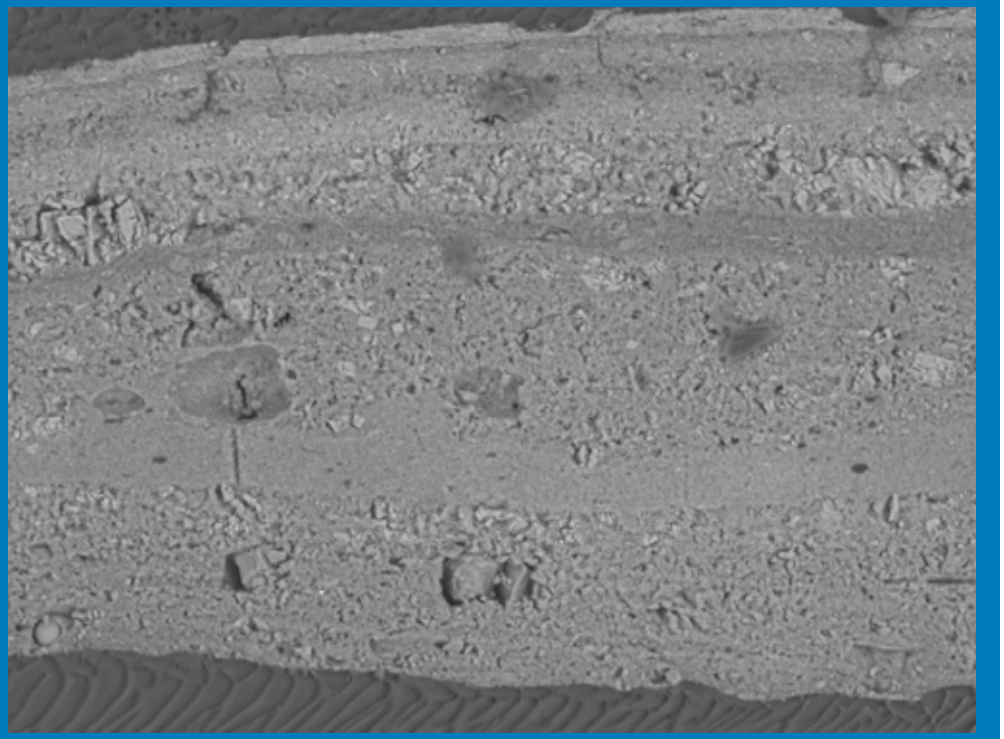
- 5 pairs remain.

Analytical Scheme



10 layer paint sample pair

off-white, interior walls



Imaged with BSE to delineate layers

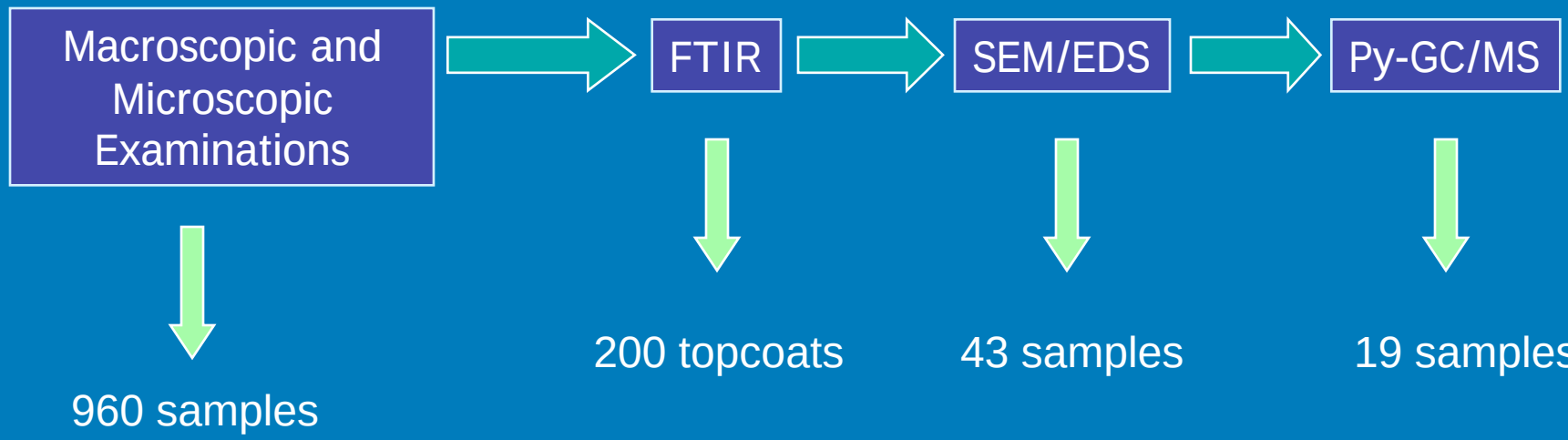
Then attempted FTIR on both surfaces of each chip.

Neither FTIR nor SEM could discriminate samples within this pair.

SEM/EDS

- 31 additional pairs (27 samples) analyzed from hued samples. BEI and EDS discriminated 24 pairs.
- 10 pairs (14 samples) analyzed from white/ off-white group. 7 pairs discriminated.

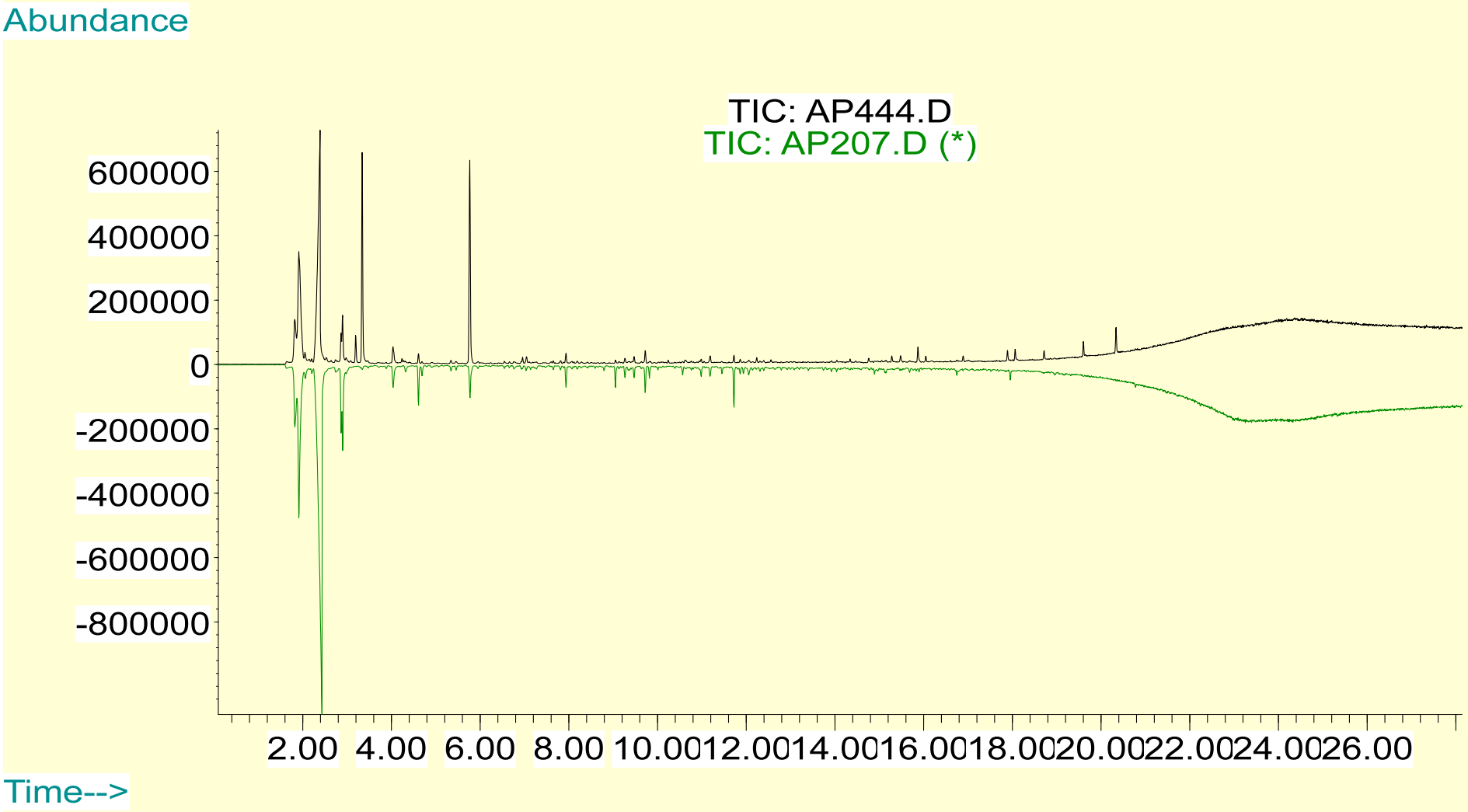
Analytical Scheme



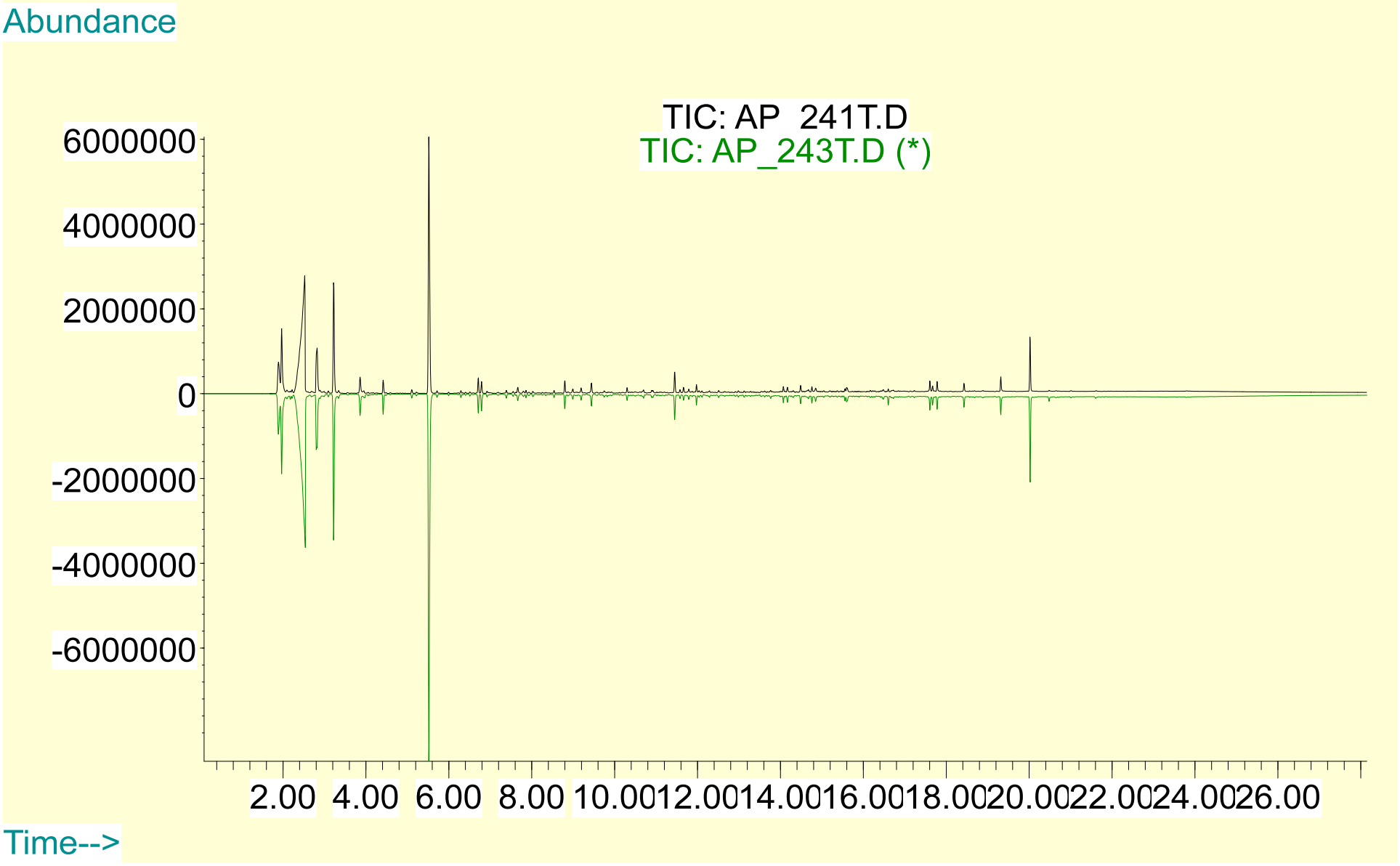
Py-GC/MS

- 7 pairs (14 samples) of hued paints analyzed.
  - One discriminated, leaving 6 indistinguishable pairs.
- 4 pairs (5 samples) analyzed from white/off-white group.
  - One pair of 2-layer samples: white over cream
    - Both layers – indistinguishable
  - Three 2-layer samples: white over cream
    - Both layers – indistinguishable

Pair discriminated by Py-GC/MS



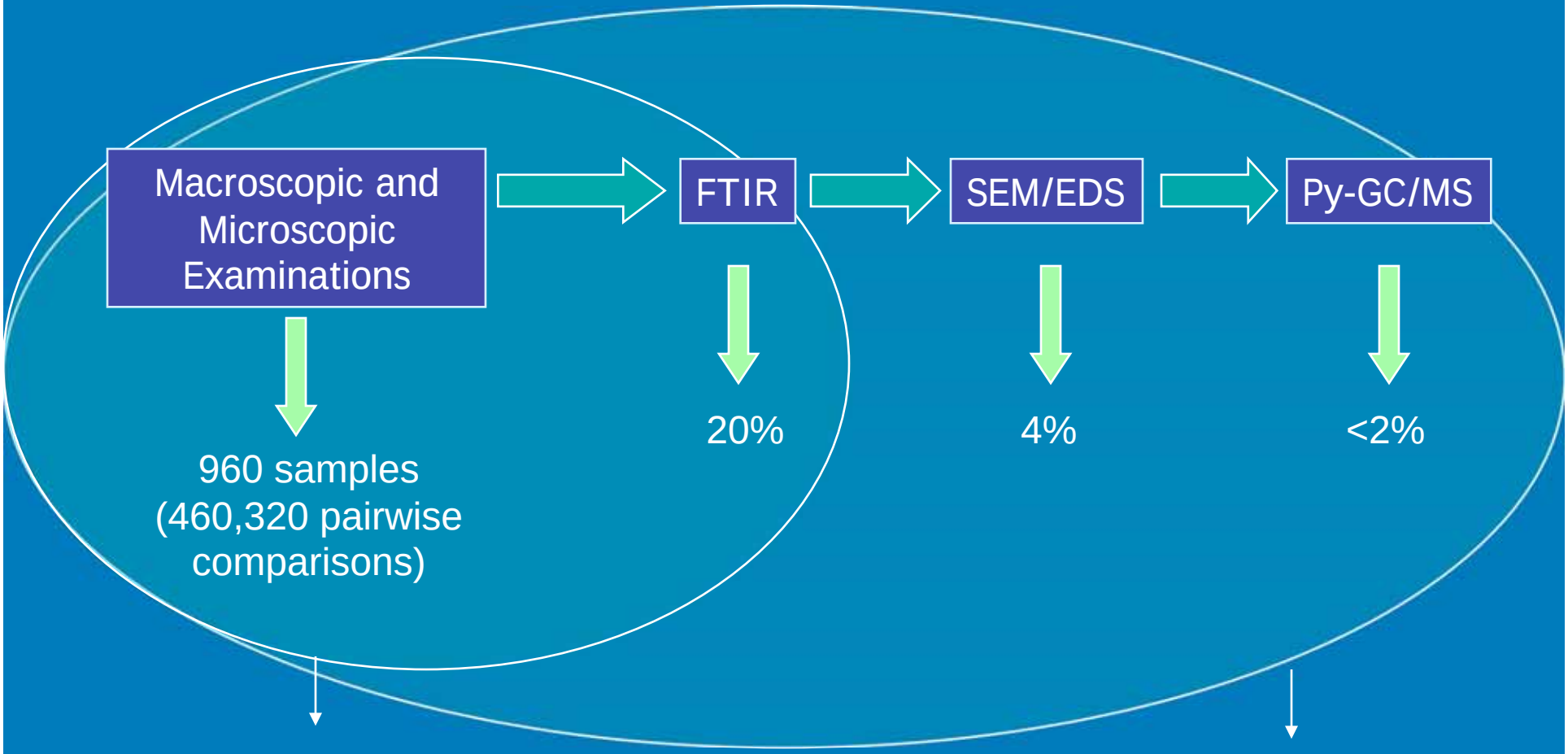
Pair not discriminated by Py-GC/MS



Discrimination Summary

- Over 950 samples submitted and evaluated
- One 10+ layered pair indistinguishable through SEM
- Ten pairs indistinguishable through Py-GC/MS

Analysis Needed for Discrimination



Indistinguishable Pairs

Pair Number	Topcoat Color	# of layers
1	(Dark) Blue	1
2	Brown, Green	1
3	Cream	2
4	Yellow	2
5	White	2
6	White	2
7, 8, 9	Off-white	2
10	Off-white	2
11	Off-white	10

Conclusions

- Tippet found that two pairs of samples from different sources were comparable. Sample pairs originating from the same source were not included in the discrimination power.

- For each indistinguishable pair in this study, the samples were collected from the same building/structure.

Therefore, no random pairs were observed to be indistinguishable in this study.

Conclusions

- Macro/microscopic exams in combination with FTIR remain the most powerful discriminators for architectural paint systems.
- SEM/EDS and Py-GC/MS can provide additional discrimination and should be utilized if available.
- Single layered or neutral colored samples can contain enough characteristics to allow for a strong association in a comparative architectural paint examination.

Acknowledgements

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