Characterization of Four Modern Papers

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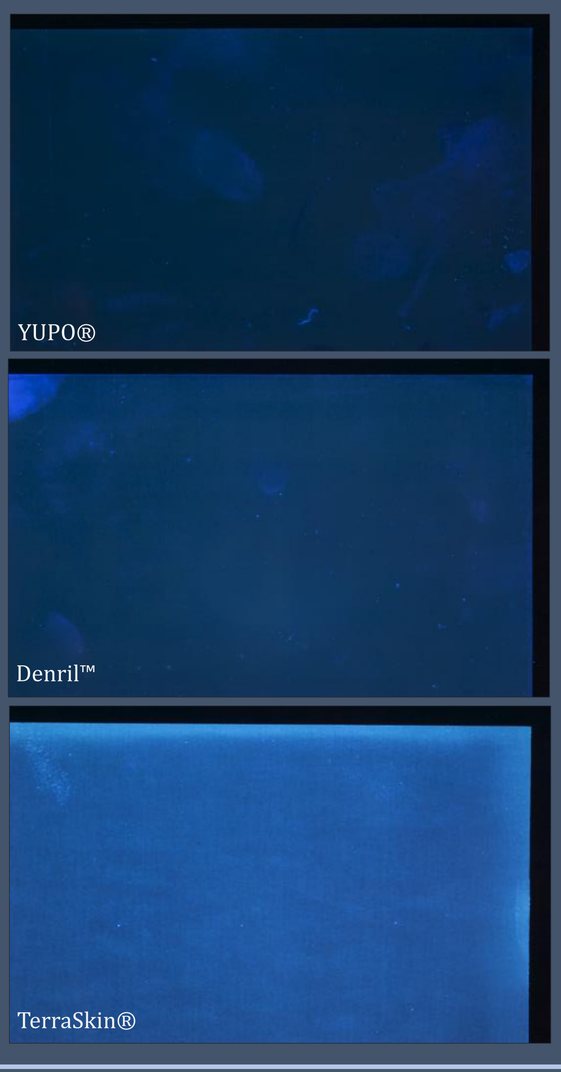
Introduction

Modern, synthetic papers YUPO® (Yupo Corporation), Denril™ (Borden & Riley), TerraSkin® (Design and Source), and PLIKE® (Gruppo Cordenons) are increasing in popularity with contemporary artists. Works of art on these supports can be found in the permanent collections of (and on exhibit at) museums such as the Museum of Modern Art and the British Museum. However, these papers are not "paper" in the traditional sense, but rather composite materials, manufactured to have paper-like qualities with surfaces that are responsive to diverse media and applications.

YUPO, Denril, TerraSkin, and PLIKE were characterized with multimodality imaging, reflected light microscopy, X-ray fluorescence (XRF), attenuated total reflection Fourier-Transform Infrared spectroscopy (ATR-FTIR), scanning electron microscopy (SEM-EDS), and, for PLIKE only, Pyrolysis-Gas Chromatography-Mass Spectrometry (Py-GC-MS).

UVA-induced visible fluorescence

UVA-induced visible fluorescence of YUPO, Denril, and TerraSkin revealed evidence of oil absorption, from handling, and fading at the edges, from exposure to light.



Conclusions & Future Research

This research provides a preliminary characterization of YUPO, Denril, TerraSkin, and PLIKE.

YUPO, Denril, and TerraSkin are polyethylene- and/or polypropylene-based, while PLIKE has a cellulose core.

Topography is identical on each side, indicating that there is no preferential side for use (SEM-EDS).

Surface coatings are predominately calcium-based, with added components (ATR-FTIR and XRF). $CaCO_3$ is likely added for color and opacity, and to enhance the acceptance of media (YUPO, Denril, and TerraSkin).

Polyethylene and polypropylene are thermoplastic polymers that offer some chemical resistance; however, they have poor long-term stability, especially upon exposure to UV radiation, oxygen, heat, and high relative humidity. [6]

The fading and marks from handling suggest these papers should be stored and displayed with UV filtration and controlled RH, and handled with gloves.

Areas for further investigation:
- Aging studies (light, heat, and moisture),
- Interactions between surface coatings and media,
- Solubility and effects of cleaning of surface coatings,
- Characterization of PLIKE colorants, and their effects on long-term stability. [5]

YUPO

Manufacturer's Information

*Information obtained from research samples

Manufacturer: Yupo Corporation

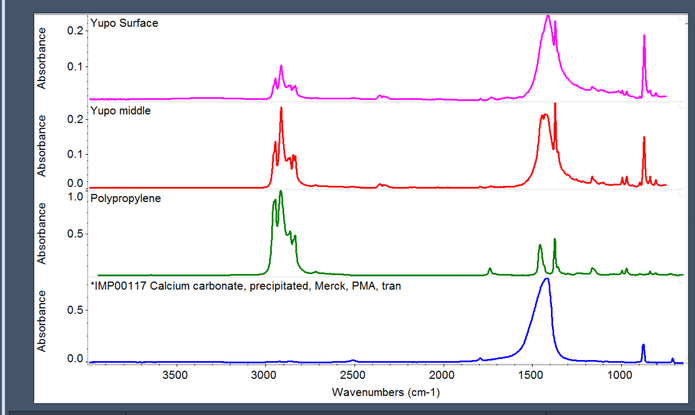
Structure: Polypropylene film with two finishing layers (YUPO original)

Composition: Polypropylene, polyethylene, calcium carbonate ($CaCO_3$), and proprietary additives

- Extrusion sheet formation
- Tree-free
- Waterproof
- Chemical-, stain-, and tear-resistant
- Smooth, satiny surface finish, semi-translucent to opaque
- Recyclable
- Resin degradation may occur at high temperatures and with oxidizing agents
- Thermal decomposition may generate carbon monoxide, carbon dioxide, acetaldehyde, hydrocarbons, and oxidized hydrocarbons
- Combustible over 320°C [1]

* Off-white in color

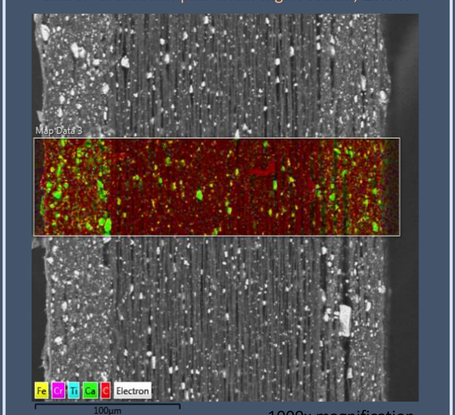
ATR-FTIR & XRF



		Surface Coating	Core
ATR-FTIR	Matching spectra:	polypropylene calcium carbonate ($CaCO_3$)	polypropylene
XRF	Elements:	Al, Si, S, Ca, Ti, Fe	n/a
	Analysis:	Highest Ti content of four papers. Second-highest Ca.	
Notes	ATR-FTIR analysis confirms core is polypropylene, although polyethylene was not identified (possibly because it is molecularly similar to polypropylene). Titanium in the coating (XRF) possibly added as a brightening agent.		

SEM-EDS cross section

Carbon coated samples under high vacuum, 15.0kV

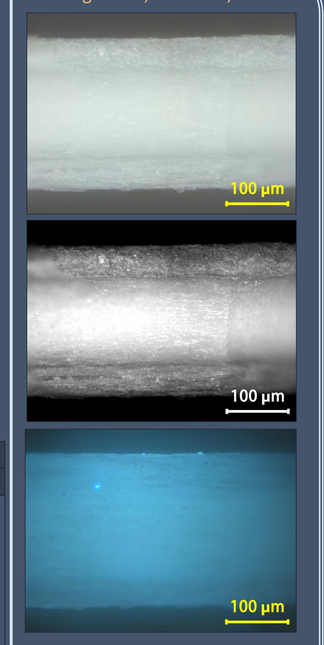


1000x magnification

Elemental Analysis	
Primary: Ca, Fe, Cr	Trace: Ti
Notes	Directional and linear structure of core likely from manufacturing process. Uniform particle size and distribution. Particles visible between linear polymer strands in core. Coating more dense than core.

Micrographs

Brightfield, Darkfield, UV



Denril

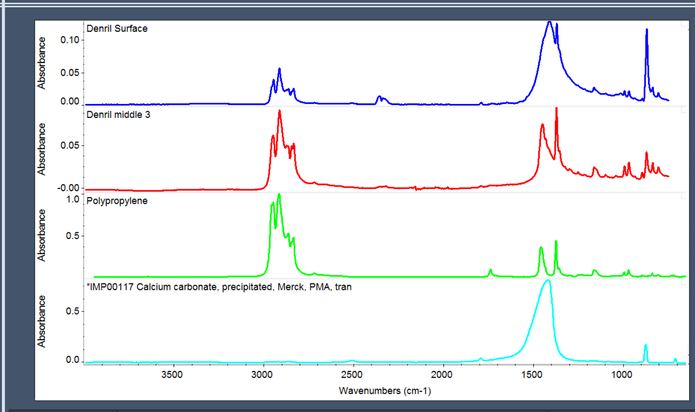
Manufacturer: Borden & Riley

Structure: Smooth, translucent surface with matte finish on both sides

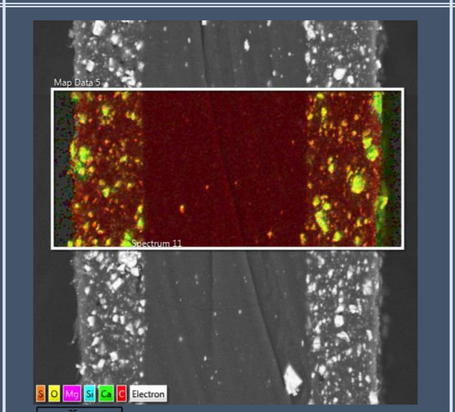
Composition: Polypropylene

- Tough
- Waterproof
- Multi-media vellum that combines the best features of paper and film
- Does not discolor or crack [2]

* Creamy-white in color

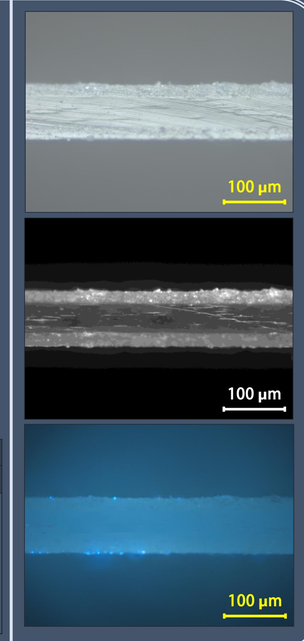


		Surface Coating	Core
ATR-FTIR	Matching spectra:	polypropylene calcium carbonate ($CaCO_3$)	polypropylene
XRF	Elements:	Al, Si, S, Ca, Fe	n/a
	Analysis:	Elemental make-up similar to others analyzed.	
Notes	Waxy consistency observed in core when sheet was split for analysis.*		



1000x magnification

Elemental Analysis	
Primary: Ca, O	Trace: Mg, S, Si
Notes	Solid core has few, or no, particles. Particles concentrated in surface layers. Elemental composition (Mg, Si, Ca, S) similar to TerraSkin, with talc and calcium carbonate components.



TerraSkin

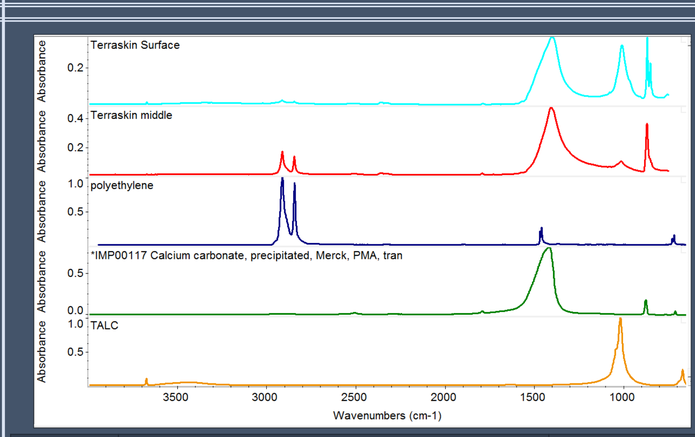
Manufacturer: Design & Source

Structure: Polyethylene resin coated with calcium carbonate

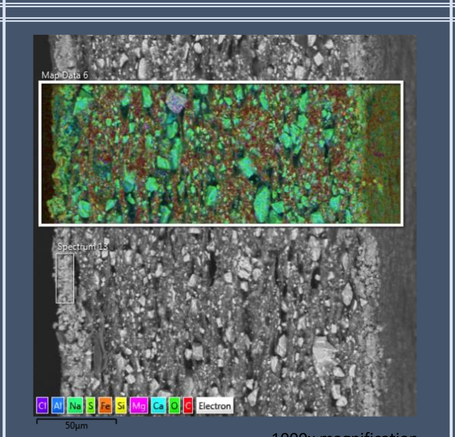
Composition: Mineral Powder (or > 80% calcium carbonate) and a small quantity of non-toxic resin (<20% PE) which acts as a binder

- Production requires no water, bleach, or harvesting of trees
- Water-, grease-, and tear-resistant
- Acid-free
- Cradle to Cradle (C2C) certified Silver
- Sustainable, recyclable, eco-friendly
- Degradation occurs in presence of heat, UV radiation, and water
- Thermoplastic [3, 4]

* Pliable and supple, opaque
* Creamy white in color
* Pliable sheet susceptible to handling creases
* Discontinued?



		Surface Coating	Core
ATR-FTIR	Matching spectra:	calcium carbonate ($CaCO_3$) talc	polyethylene
XRF	Elements:	Ca, S, Mg, Si, Fe, Zn	n/a
	Analysis:	Most Ca and S of four papers.	
Notes	Evidence of Cs, S, Mg, Si, Fe, and Zn are likely component parts of the "stone" used in manufacture. Sheet pliability likely due to polyethylene core – a less rigid polymer than polypropylene.		



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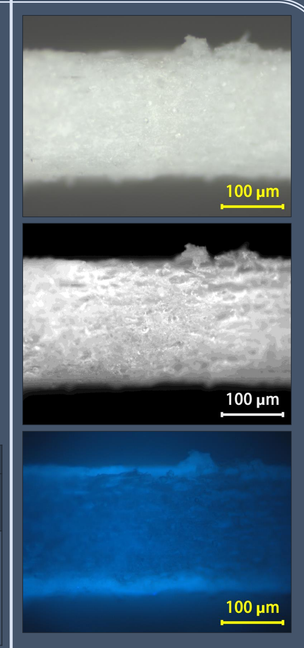
Elemental Analysis	
Primary: Ca, O	Trace: Fe, Mg, Si, Cl, Al, Na, S
Notes	Fine particles on surfaces with coarse particles in the core. Si, Mg, and Ca are likely components of the "stone" surface coating.



PLIKE

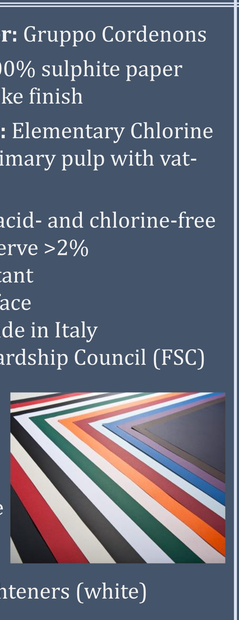
Manufacturer: Gruppo Cordenons

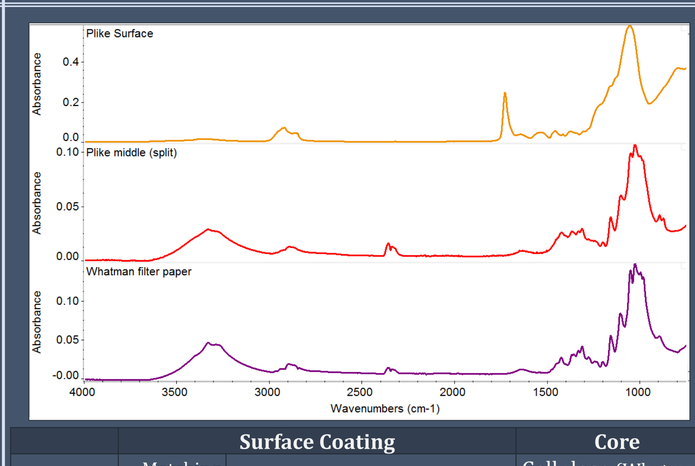
Structure: 100% sulphite paper with plastic-like finish

Composition: Elementary Chlorine Free (ECF) primary pulp with vat-dyed coating

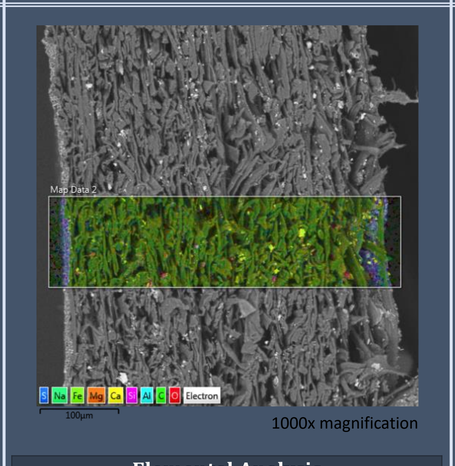
- pH neutral, acid- and chlorine-free
- Alkaline reserve >2%
- Water-resistant
- Smooth surface
- Machine-made in Italy
- Forest Stewardship Council (FSC) Certified
- Recyclable
- Available in 9 colors [5]

* Stiff, opaque
* White in color
* Optical brighteners (white)





		Surface Coating	Core
ATR-FTIR	Matching spectra:	n/a	Cellulose (Whatman filter paper)
XRF	Elements:	Al, Si, S, Ca, Ti, Fe	n/a
	Analysis:	Highest Al, Si, and Fe content of four papers.	
Notes	No evidence of calcium carbonate in the surface coating as seen with the other papers.		



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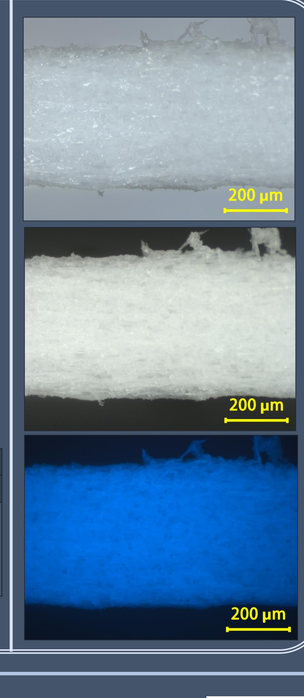
Elemental Analysis	
Primary: Ca, O, Al, Si	Trace: Mg, Na, Fe, S
Notes	Al and Si on surface only. Fine particles in surface coating. Core is macerated cellulose.



Acknowledgements & References

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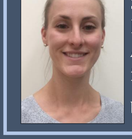

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