

# Preparation of a Synthetic Indian Yellow

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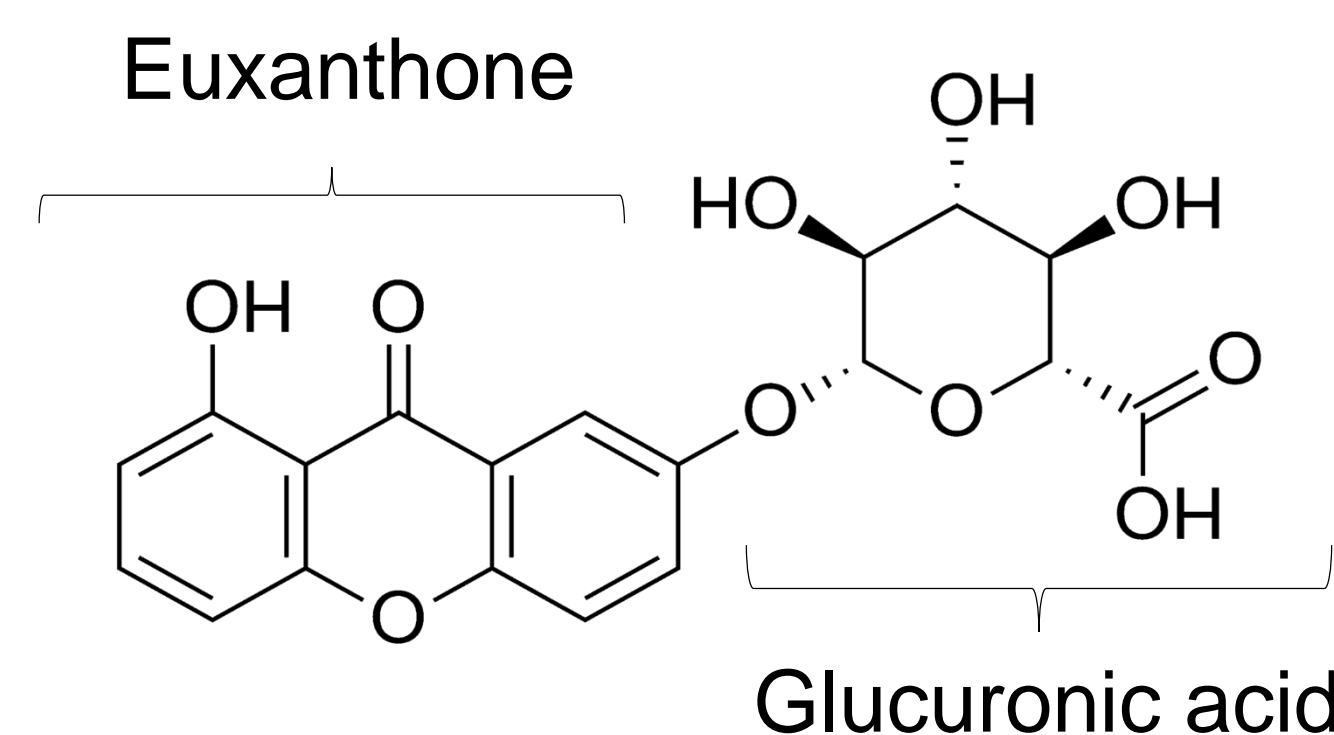


## Introduction

Indian yellow is a yellow-orange pigment (Fig. 1) often reported as being extracted from the urine of cows fed only mango leaves (*Mangifera Indica*). The production of Indian yellow was banned around 1910 due to the inhumane nature<sup>1</sup>. The relative chemical un-reactivity of the constituents, euxanthone and glucuronic acid (Fig. 2), has made production of a synthetic version difficult. A new method was developed to form a synthetic compound that mimics that spectral properties, including the characteristic fluorescence (Fig. 3) of Indian yellow, by substituting various surrogate groups at the glucuronic acid binding site.



**Figure 1.** A solid orange ball of Indian yellow pigment (Forbes Collection).



**Figure 2.** Chemical structure of Indian Yellow (Euxanthic acid).

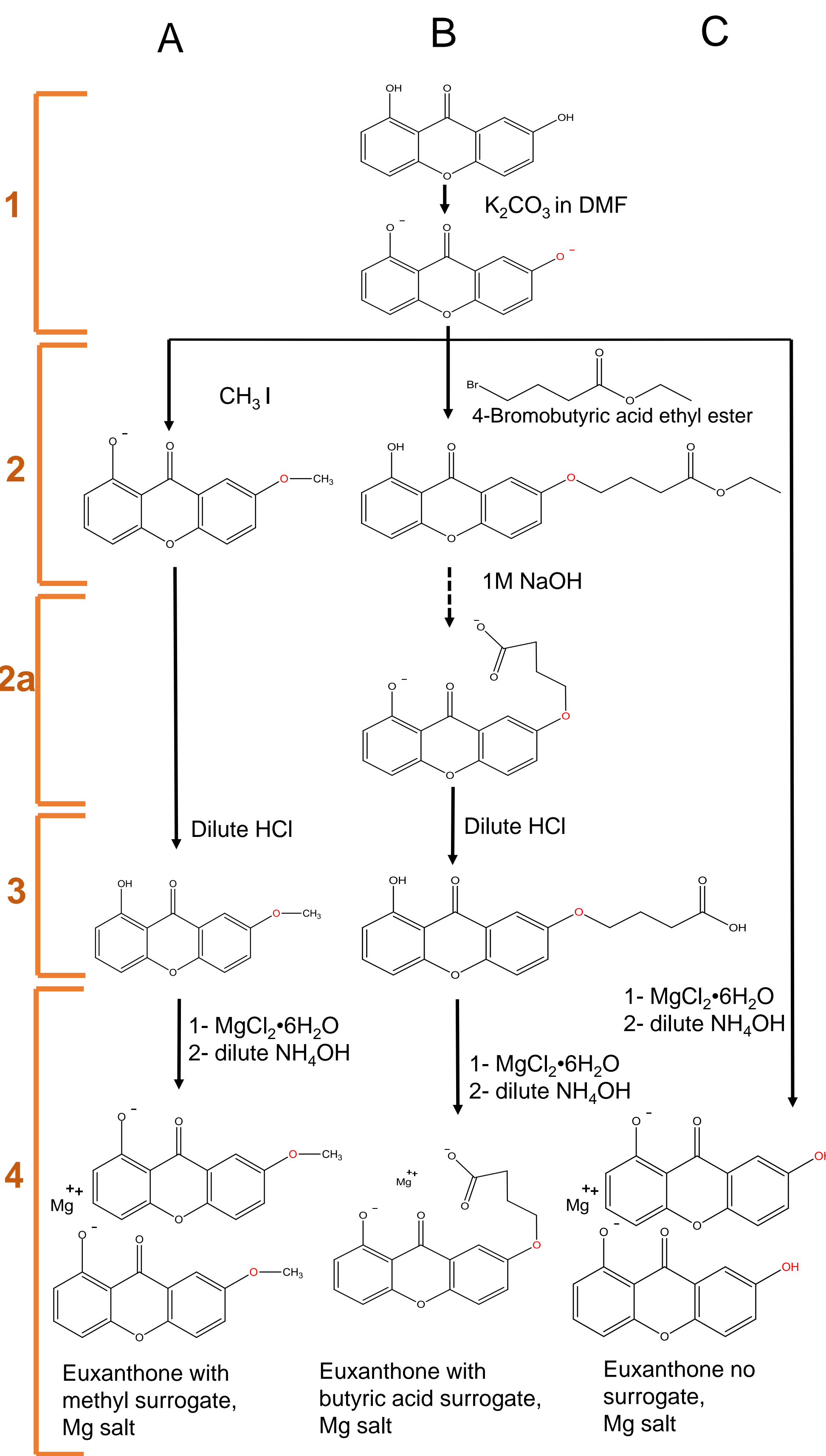


**Figure 3.** Photographs of a watercolour pigment book under normal (a) and UVA (b) illumination illustrating the fluorescence characteristics.

## Experimental and Synthesis

Euxanthone and the various surrogate groups were reacted together followed the reaction schemes 1 (A,B,C). Characterization was performed with  $\mu$ -FTIR (Thermo, Contium), Raman spectroscopy (Bruker, Senterra), XRD (Bruker, D8 Venture), py-GC-MS (Frontier 2020 pyrolyzer, GC-MS Agilent). Samples were exposed to UVA radiation for imaging. Results for the  $\mu$ -FTIR, Raman Spectroscopy and XRD will be discussed here.

**Scheme 1. A, B, C: Synthesis of euxanthone based magnesium salts**



**Step 1** – Deprotonation of euxanthone (red solution)



**Step 2** – Addition of surrogate groups: A: methyl iodide; B: 4-Bromobutyric acid ethyl ester

**Step 2a** Saponification of ethyl ester in B

**Step 3** Acidification to generate the free form acid (pale yellow precipitate)

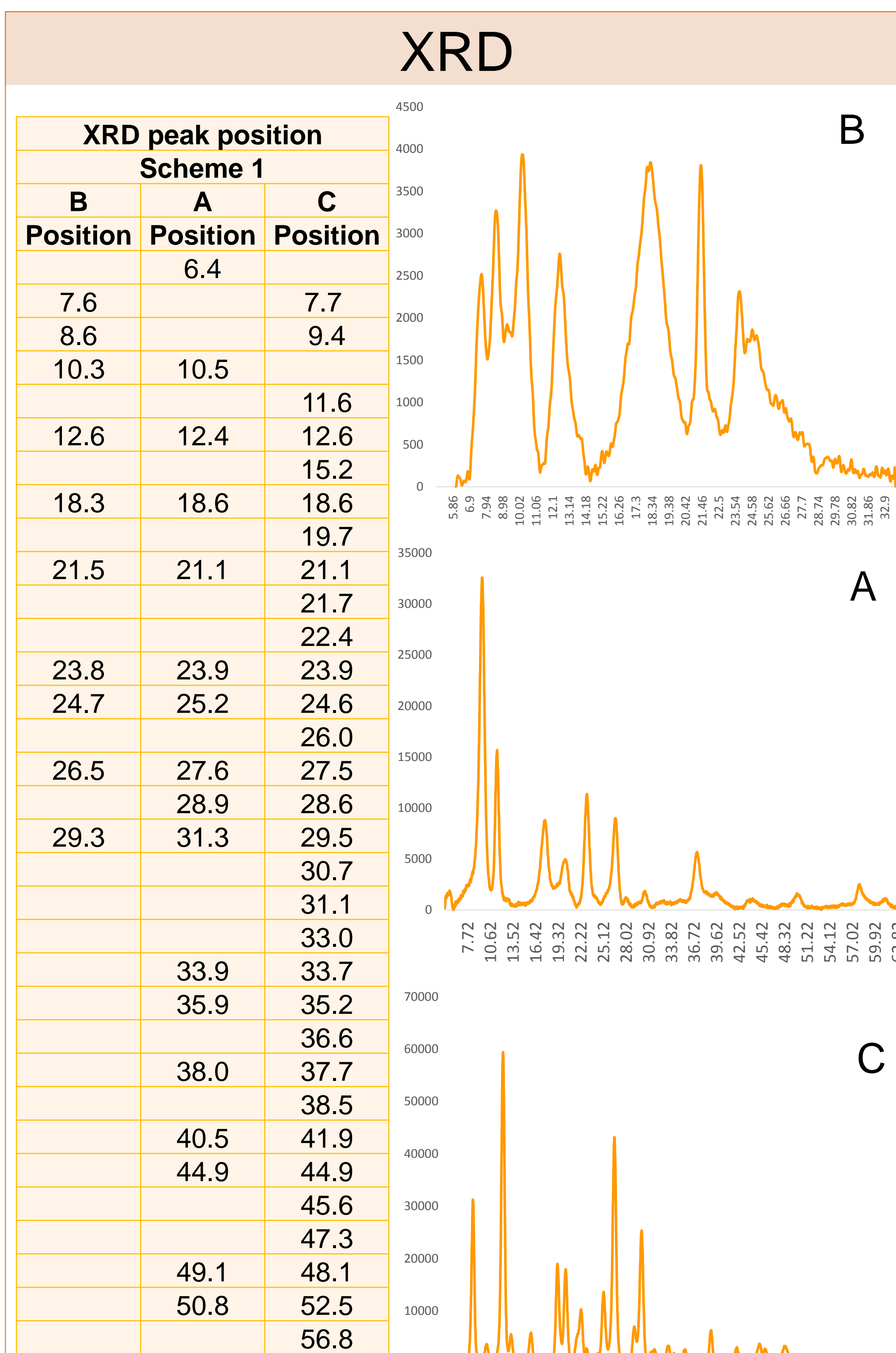


**Step 4** Formation of magnesium salt (dark yellow precipitate)



**Figure 6.** Formation of three surrogate Indian yellows by forming magnesium salts of a (A) methylated euxanthone, (B) carboxylated euxanthone, and (C) unsubstituted euxanthone. Yellow products were photographed under normal (left) and UVA (right) illumination.

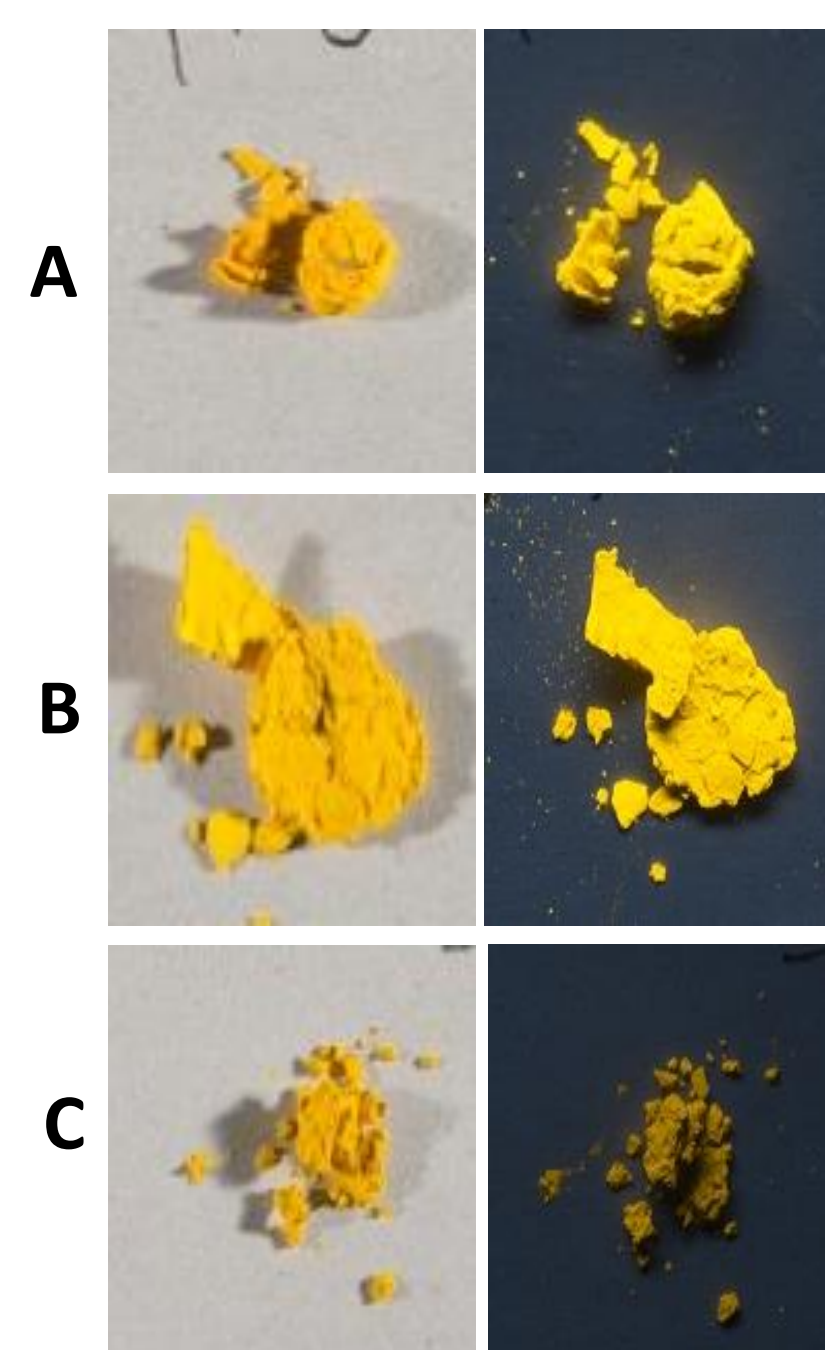
## Results



**Table 1.** XRD peak positions of the synthesis products from scheme 1. B, A, and C.

**Figure 4.** XRD spectra of the synthesis products from scheme 1. B, A, and C.

## UVA Fluorescence



**Table 2.** Origin of the peaks in the FTIR and Raman spectra of the products of schemes B, A, and C.

Origin	FTIR	Raman
OH	3500-2962, 1149	-
Symmetric CH <sub>2</sub> stretch	2962*	2913**
C=O (ketone)	1619	1631
Aromatic	1588, 1108, 719, 697	-
Ether	1270*, 1233	-
C=C stretch	-	1546
Ring stretch	-	1421*, 1370*
Ring vibrations	-	1234
Ring breathing	-	1168*, 988*, 694
Ring deformation	-	514*

\*Slight variation between samples; \*\* Not observed in Scheme A

## Conclusion

To this point, synthesis of Indian yellow substitutes have produced precipitates of similar colour and fluorescence to known Indian yellow. Characterization is ongoing, and will be compared to the Forbes collection and Winsor & Newton late 19<sup>th</sup> century watercolour paint-outs. Further investigation will be done on the wavelength of fluorescence of the surrogates compared authentic Indian yellow.

## References

1) Feller, R. L., Roy, A., FitzHugh, E. W., & Berrie, B. H. (1986). *Artists' pigments: A handbook of their history and characteristics*. Washington: National Gallery of Art.

## Acknowledgements

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