Creating new colors from curcumin and its derivatives

The effect of derivatization trough condensation on curcumins color and stability

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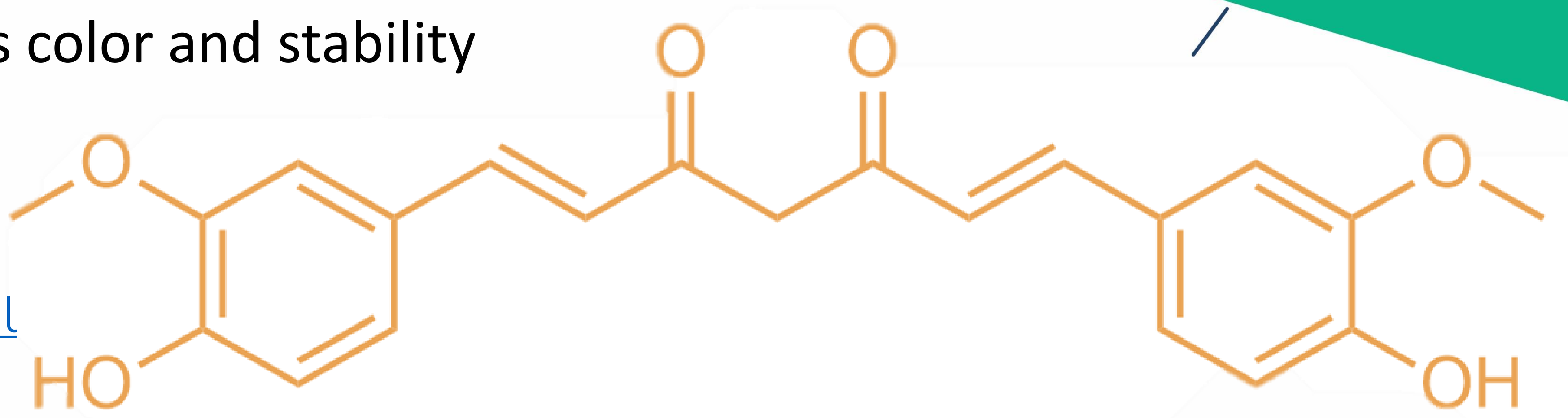
Date: 16-01-25

MNEXT MATERIALS & ENERGY X TRANSITION



Introduction

Curcumin, the colorant found in turmeric, has a vivid yellow to orange color but lacks stability under UV radiation. [1] EcoPro explores curcumin as a biobased alternative for petrochemical-based colorants, to be used in various applications, such as packaging. By means of derivatization, its conjugated system can be extended, altering its wavelength and color. Former student W. Post [2] stabilized curcumin to di-benzoylcurcumin (**1**) by protecting its phenols, avoiding oxidation, leading to higher UV-stability.

This project aims to further derivatize **1** to di-benzoyl benzylidene curcumin (**2**) and di-benzoyl 4-hydroxybenzilidene curcumin (**3**) through condensation with benzaldehyde and 4-hydroxybenzaldehyde, followed by boron complex formation to yield the final product 4-hydroxybenzylidene rubrocurcumin (**4**); which is expected to have a red or purple color and which will be analyzed using ^{1}H-NMR, FTIR, HPLC, UV-VIS and TLC, and compared with properties of curcumin and its derivatives (**1** – **3**).

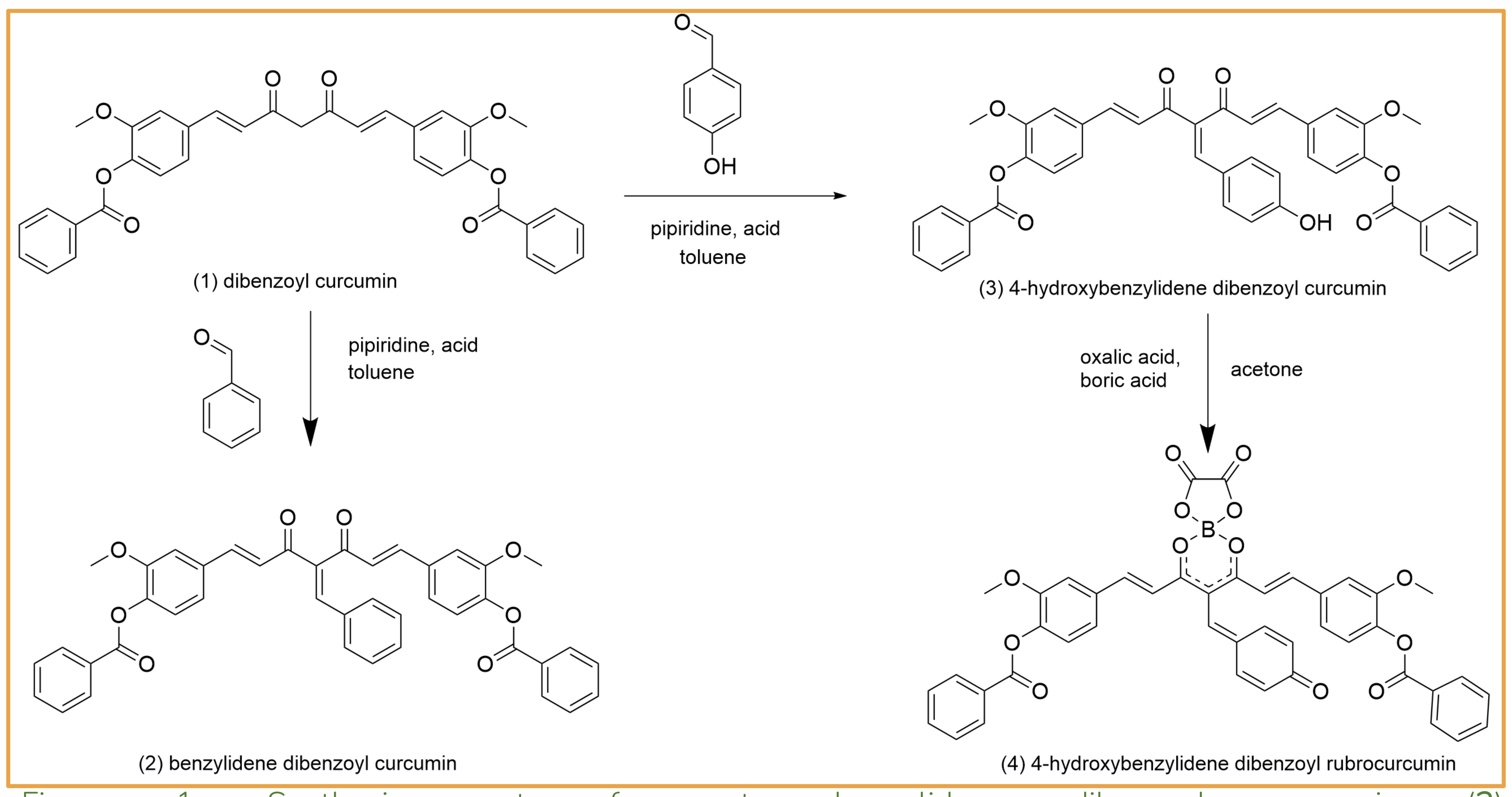


Figure 1: Synthesis route from to benzylidene dibenzoyl curcumin (2), 4-hydroxybenzylidene dibenzoyl curcumin (3) and 4-hydroxybenzylidene dibenzoyl rubrocurcumin (4)

Tautomerism of curcumin involves the reversible conversion of di-keto curcumin into its keto-enol form (Figure 2). The ratio of tautomers depends on the environment, but the keto-enol form is required to form a boron complex. **2** is locked in di-keto form and is unable to form the complex. 4-hydroxybenzaldehyde is introduced because of its resonance abilities and, supporting the keto-enol form of **3**.

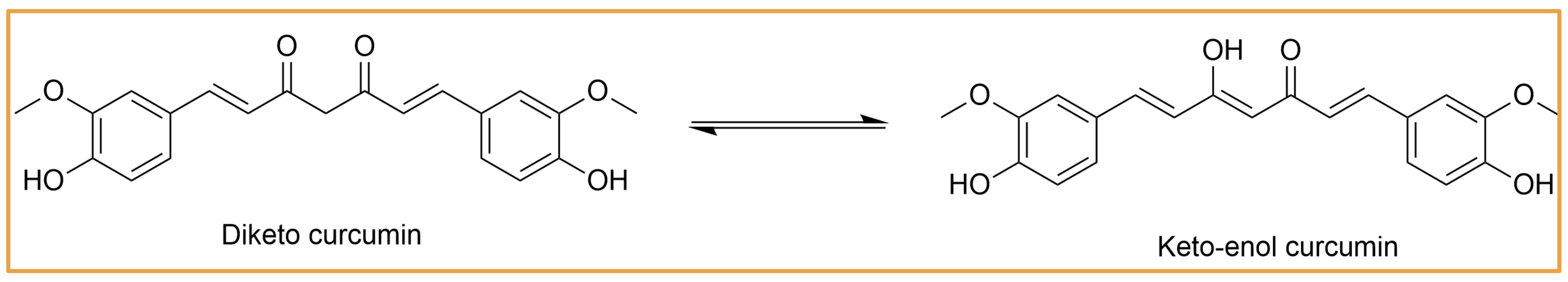


Figure 2: Keto-enol tautomerism of curcumin

Experimental

Condensation of dibenzoyl curcumin (**1**) was performed using the method of J. Lal *et al.* [3] with 3 mmol (approx. 1.8 grams) of starting material, in a 1:2 ratio with benzaldehyde. Work-up included washing with acid (pH = 4), base (pH = 8), followed by purification using preparative TLC. Yield obtained was insufficient to perform further analysis.

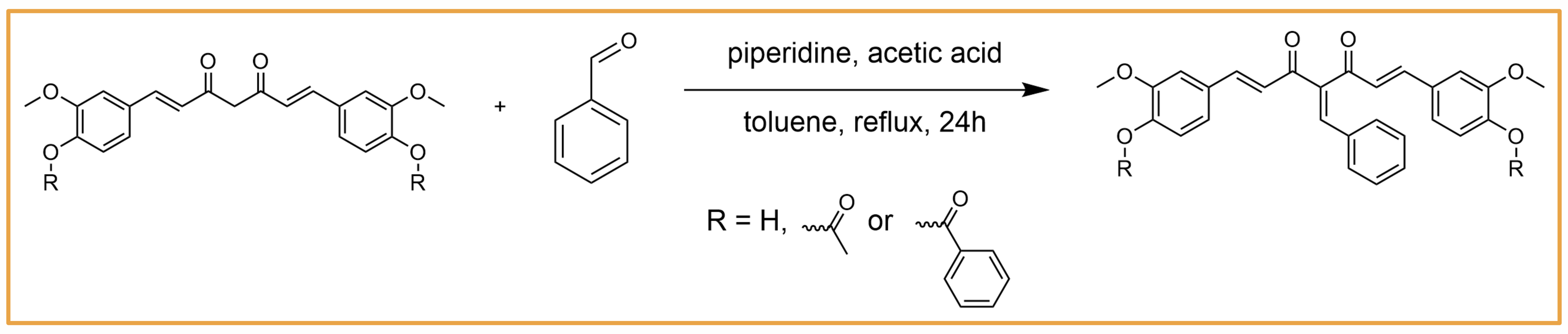


Figure 3: Synthesis route of benzylidene curcumin and benzylidene di-acetylcurcumin

Due to low yield of **2**, synthesis was initially conducted with 3 mmol of curcumin to validate the method. Subsequently, synthesis was performed with 3 mmol of di-acetyl curcumin (DAC) to determine the impact of phenol protection in the method. Benzylidene curcumin (BenzC) was obtained by cooling down the reaction mixture and washing the precipitate with water and washing the filtrate with brine. ^{1}H-NMR analysis was carried out with 60 mg of sample dissolved in 0,5 mL of DMSO-d_6.

Results

TLC pure product **2** was obtained with prep TLC. Further analyses were carried out on BenzC. Synthesis from DAC was unpromising, due to overnight solvent evaporation and degradation.

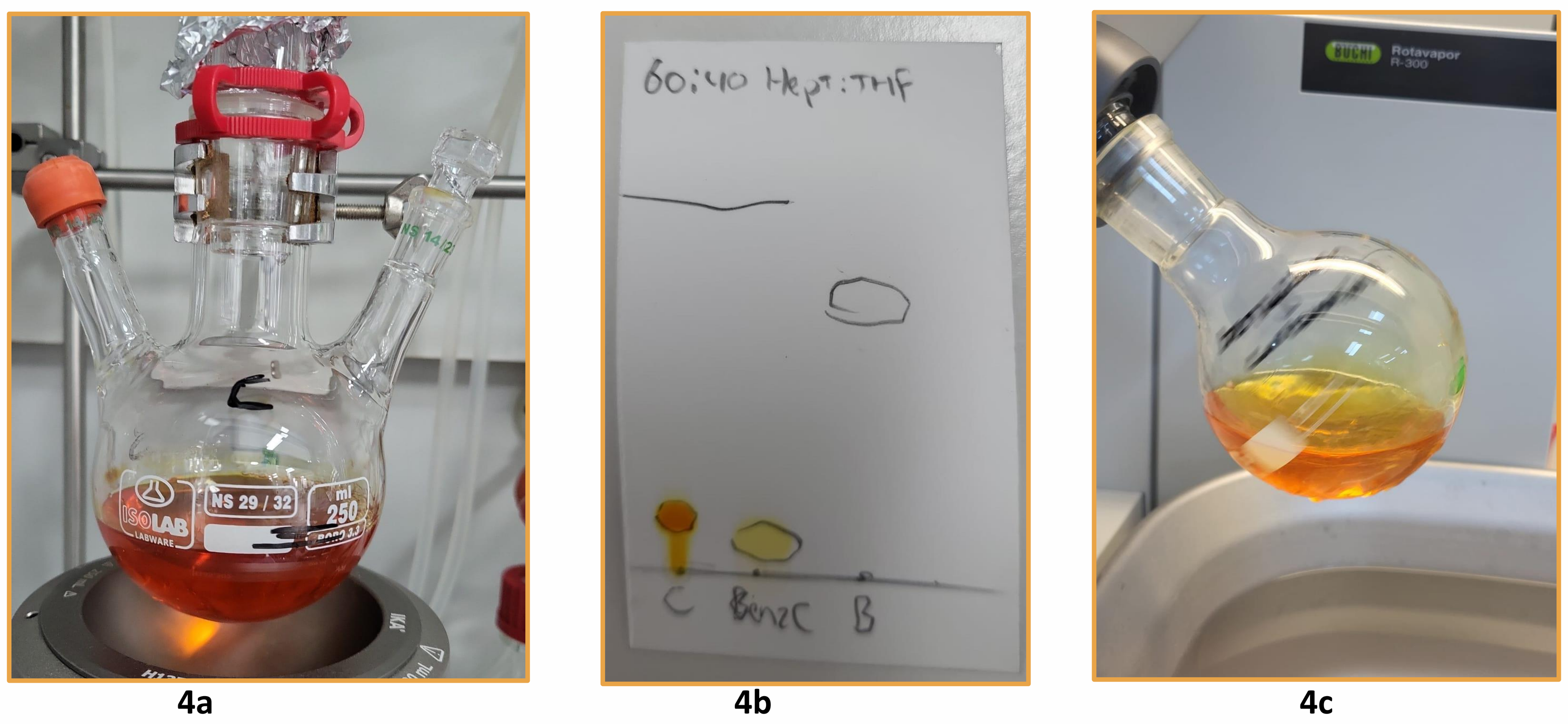


Figure 4: **a)** synthesis of BenzC; **b)** TLC of C (curcumin) Rf=0,19; BenzC Rf=0,1; B (Benzaldehyde) Rf=0,75 **c)** solvent evaporation of leftover precipitate

After washing the precipitate with water, product was TLC pure. Yield was 2,4 mmol (79 %).

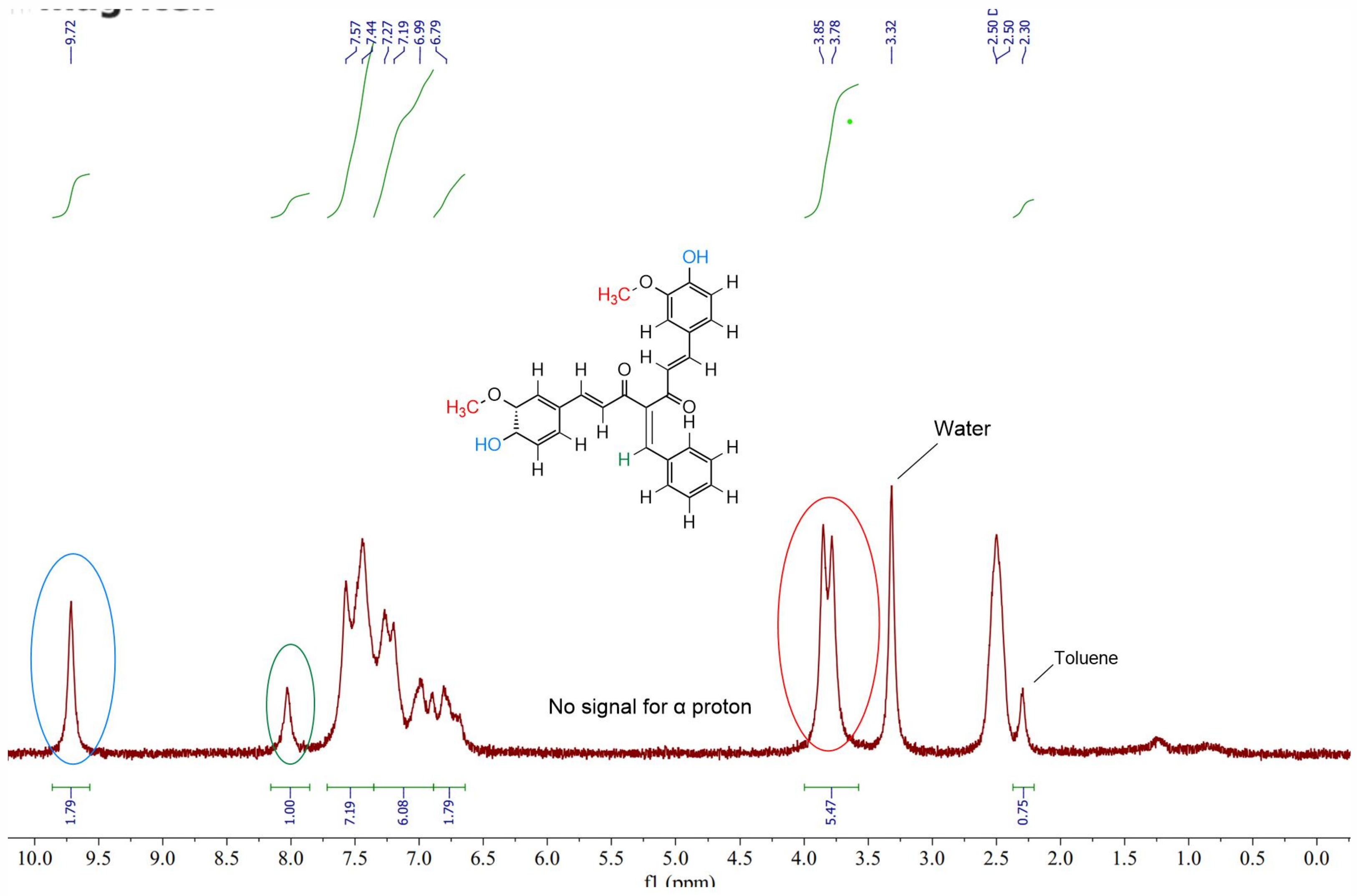


Figure 5: H-NMR spectrum of the product, indicating the formation of BenzC. (60 MHz)

Discussion & what's next

The ^{1}H-NMR spectrum of BenzC confirms the formation of benzylidene curcumin, with no major impurities. The absence of the α-proton in the spectrum and the TLC analysis confirm the absence of starting material.

The effect of phenol protection on Knoevenagel condensation of curcumin is to be investigated using DAC. Upon product formation on TLC, curcumin can be removed from the sample using an aqueous alkaline wash. Recommendations would be using more analyzing techniques.

Figure 6: Crude product (BenzC)

References

Special thanks to:

Interreg Europe

Co-funded by the European Union

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[2] W. Post, "Optimalisatie van syntheses van curcumine-derivaten DAC en DBC" Curcol, Breda 2023

[3] Jaggi Lal, "Chitosan: An efficient biodegradable and recyclable green catalyst for one-pot synthesis of 3,4-dihydropyrimidiones of curcumin in aques media" in *Catalysis communications*, Elsevier, India 2012, p. 38-43

[4] S. Mishra, "Synthesis and exploration of novel curcumin analogues as anit-malarial agents" in *Bioorganic & Medicinal Chemistry 16*" Elsevier, Bangalore 2008, p. 2894-2902.

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