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Kinetics and Photochemistry with a smartphone

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Introduction

An experimental laboratory activity based on a low-cost modular DIY device incorporating a smartphone[1] for the study of the kinetics of a photoinitiated reaction[2] is presented. This proposal is of particular interest for laboratory programs at both high school and undergraduate Chemistry courses. On one hand, after adapting it to the students' prior knowledge, it facilitates the learning of theoretical concepts in Chemical Kinetics and Photochemistry (kinetic equations and reaction mechanisms). On the other hand, it introduces students to experimental concepts of time-resolved spectrophotometry, with special emphasis on image-based detection ("imaging")[3].

References

1. Enríquez Palma, P. A. Puyuelo García, M. P. and cols., *Smartphone Kinetics*. VI Congreso Internacional de Didáctica de la Química, May 22-25 (2025). On-line. Asociación de Químicos de Galicia
2. Larsen, M. C., & Perkins, R. J. J. Chem. Edu., 93 (2016) 2096.
3. Brown, D. *Tracker Video Analysis and Modelling Tool for Physics Education*. Github.io. https://opensourcephysics.github.io/tracker-website

Acknowledgments

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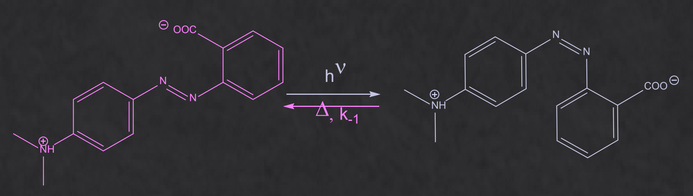
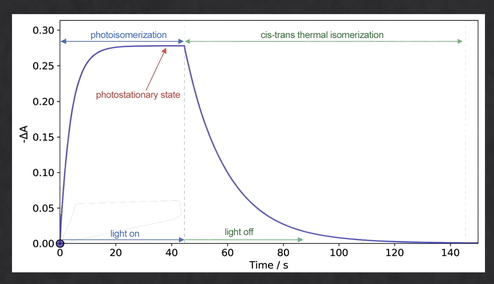
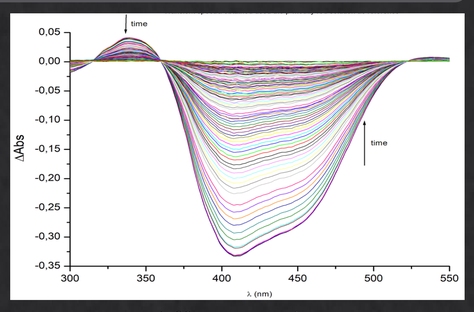
The photoinduced reaction





$$v = k_{-1}\left[cis-MR\right] \quad \left[cis-MR\right]_t = \left[cis-MR\right]_o e^{-k_{-1}t} \quad \Delta A_t = \Delta A_o e^{-k_{-1}t}$$

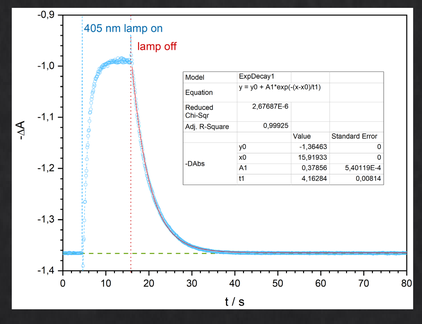
PE Lambda 265



Transient difference absorption spectra of a o-MR solution. [NaOH] = 0.12308 M

- Excitation: 405 nm LED lamp
- Single beam.
- Xe pulsed lamp.
- Detector: Multichannel Photodiode Array (PDA)
- Fixed spectral resolution ($\Delta\lambda \sim 2$ nm)
- Temporal resolution $\Delta t \geq 2$ s.
- Follow the time evolution of the absorption spectrum.

Shimadzu UV-2401 PC



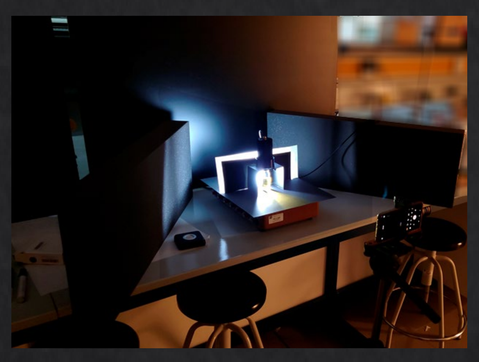
Photokinetic signal 420-425 nm for a o-MR solution (Δt = 0.1 s). [NaOH] = 7.6 10^{-3} M.

- Excitation: 405 nm LED lamp
- Double beam
- Continuous halogen lamp (VIS range)
- Detector: Photomultiplier (PMT)
- Tunable spectral resolution $\Delta\lambda$ = 0,1 – 5 nm.

Temporal resolution **$\Delta t \geq 0{,}1$ s**

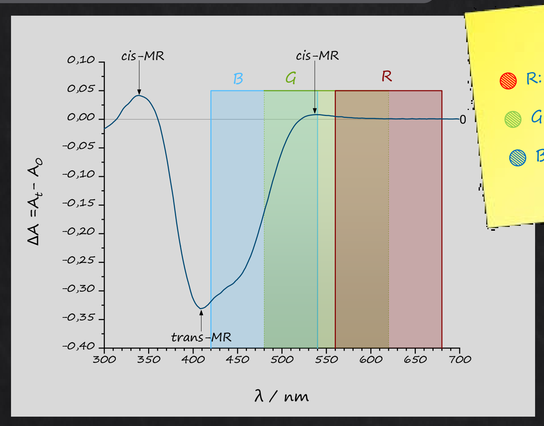
- Can not follow the time evolution of the absorption spectrum.

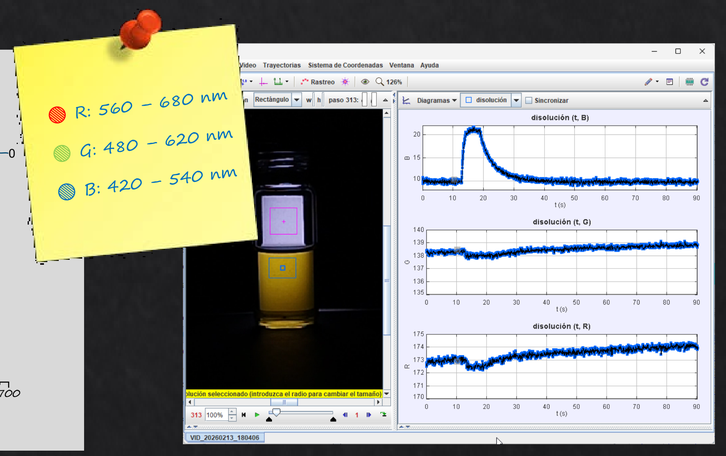
Smartphone set-up

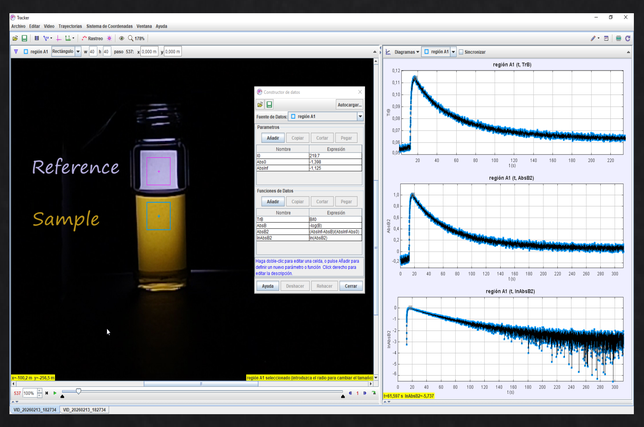


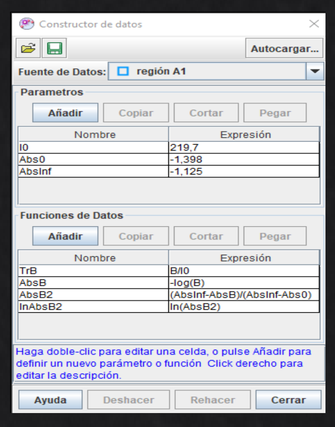
- Excitation: 405 nm LED lamp
- Light: photographic LED
- Fluxometer: 36 lux (@ camera position)
- Detector: CMOS smartphone camera (Xiaomi Redmi Note 11 Pro 5G , operated in Pro function). Fixed FPS, ISO, resolution …

Tracker video analysis

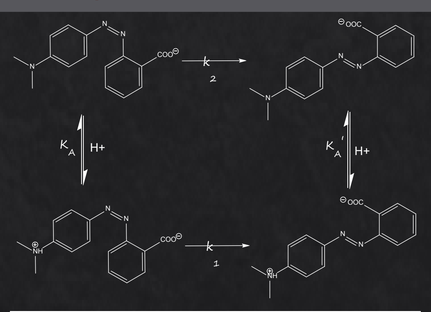






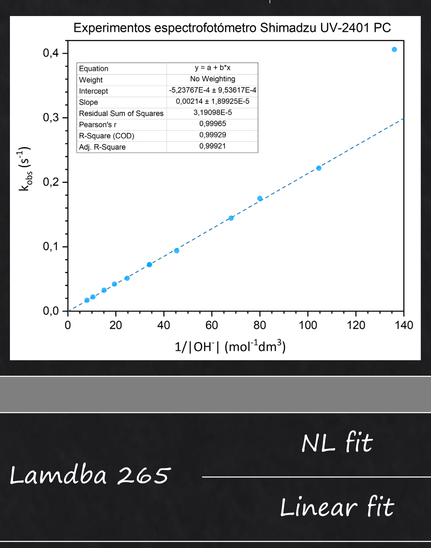


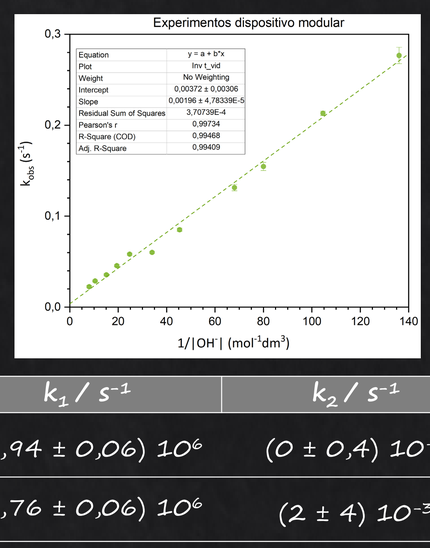
Effect of the pH on the thermal isomerization kinetics



$$v = k_1\left[C\right] + k_2\left[CH\right] = k_{obs}\left(\left[C\right] + \left[CH\right]\right)$$

$$k_{obs} = \frac{k_1}{\frac{K_A}{K_w} + \left[OH^-\right]} + k_2$$





		k_1 / s^{-1}	k_2 / s^{-1}
PE Lamdba 265	NL fit	$(1{,}94 \pm 0{,}06)\ 10^6$	$(0 \pm 0{,}4)\ 10^{-3}$
	Linear fit	$(1{,}76 \pm 0{,}06)\ 10^6$	$(2 \pm 4)\ 10^{-3}$
Shimadzu UV-2401 PC		$(2{,}14 \pm 0{,}02)\ 10^6$	$(0 \pm 1)\ 10^{-3}$
Smartphone		$(1{,}96 \pm 0{,}05)\ 10^6$	$(3 \pm 3)\ 10^{-3}$
Larsen, M. C., & Perkins, R. J. J. Chem. Edu., 93 (2016) 2096		$(2{,}6 \pm 0{,}2)\ 10^6$	$(4 \pm 12)\ 10^{-3}$