Gamma radiation induced degradation of Indigo Carmine dye on aqueous solutions

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- ***The possibility of using gamma-rays to degrade and decolorize a textile dye in water has been investigated in this study.***
- ***Indigo carmine aqueous solutions were irradiated with doses from 0.1 kGy to 5.0 kGy at 47.63 Gy/mn dose rate.***
- ***The change in absorption spectra, the degree of decoloration, the chemical oxygen demand (COD) and kinetic of degradation were examined.***

1. Indigo Carmine

The indigo carmine (IC) is one of the most widely used dyes in the textile industry, as well as acid blue 74, which is also used as an additive in pharmaceutical tablets and capsules. However, this highly toxic indigoid class of dye is carcinogenic, and can lead to reproductive, developmental, neuronal and acute toxicity and provoke tumors at the site of application .

Thus, the removal of indigo carmine from water and wastewater is a need of the highest order.

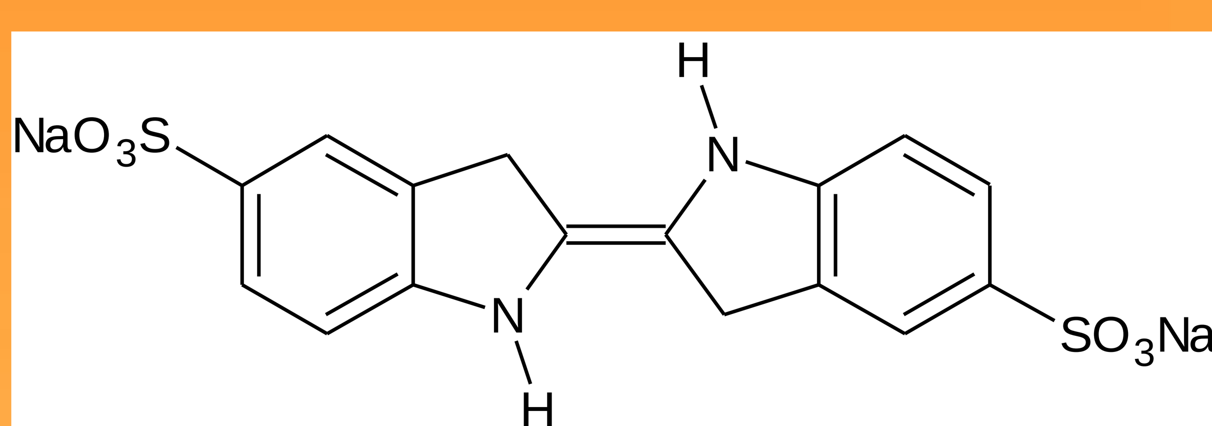

Fig. 1. *Structural chemical formula of Indigo carmine dye*

2. Gamma irradiation

The irradiation of the samples with γ-radiation was carried out using the Cobalt 60 radiation source facility of CNSTN (fig 2). The inner zone of the irradiation source building. All sample treatments were conducted at room temperature. The used dose rate at the irradation position is 47.62 Gy/mn

Fig. 2. *Indication of the irradiation position in the source building : the rate dose is measured to 47.62 Gy/min.*

The gamma irradiation of dilute aqueous solutions results principally in ionization of water molecules and product several reactive species including hydroxyl radicals, solvated or hydrated electrons, hydrogen atoms, hydronium ions…

$$H_2O \xrightarrow{\gamma} OH^{\bullet} + H^{\bullet} + H_3O^{+} + e^{-}_{aq}$$

The OH radicals are highly reactive species, able to act rapidly and non-selectively on the organic material. They cause its transformation to a biodegradable material.

3. UV- Visible Spectrophotometric analysis

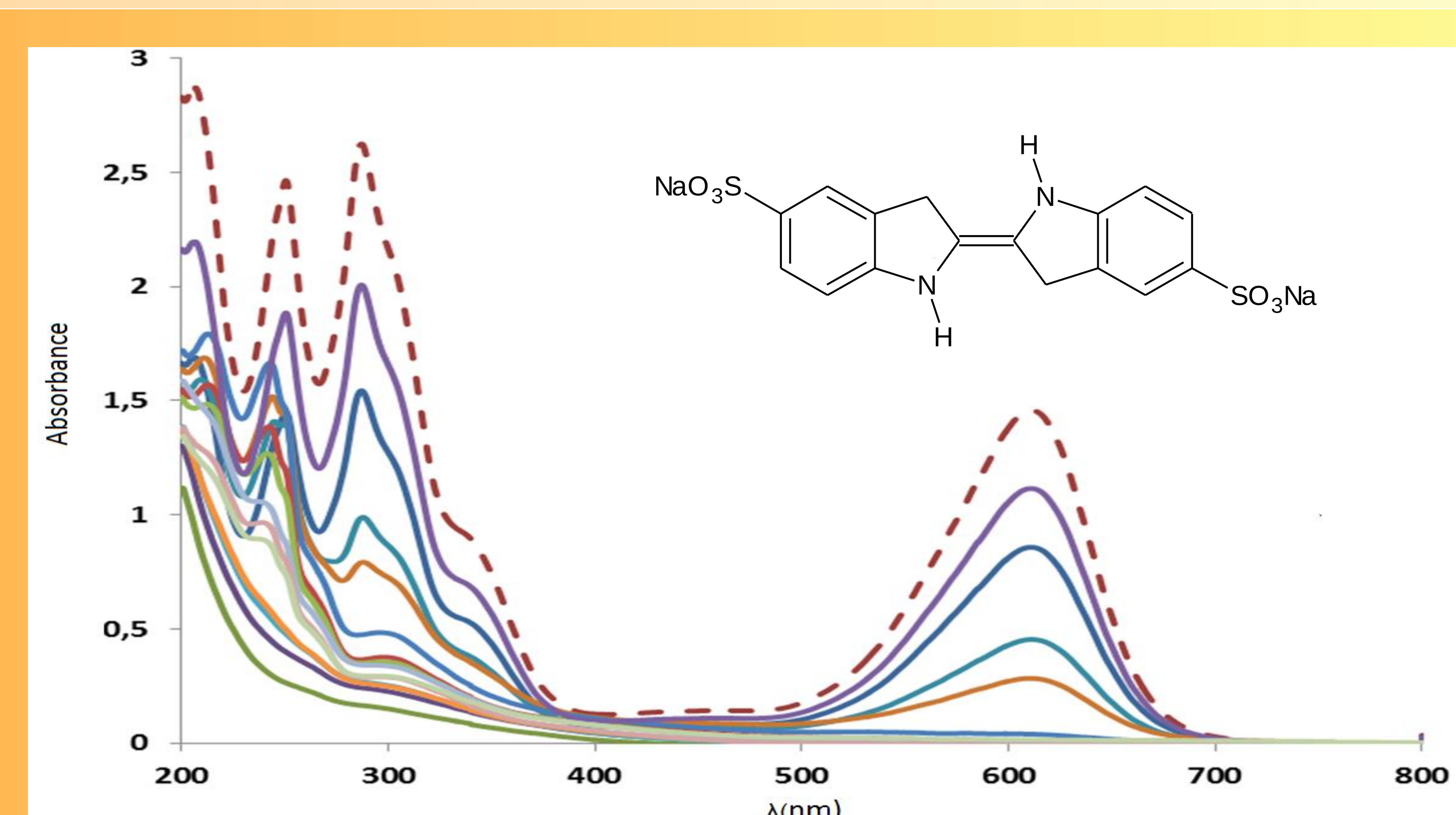

Fig. 3. *Absorption spectra of unirradiated and irradiated IC (150 mg/L) aqueous solutions at different doses (from 0.1 to 5 kGy)*

- **Before treatment:** Presence of three bands located in the UV region (**λ**=297, 249 and 203 nm**)** and a single peak located in the visible region (λ=611 nm).
- **After treatment:** for all bands, absorbance decreases with increasing irradiation dose. The absorption bands at 297, 249 and 203 nm decreased less rapidly with increasing dose than that at 611 nm and disappeared almost completely at 5 kGy.

4. Kinetic study

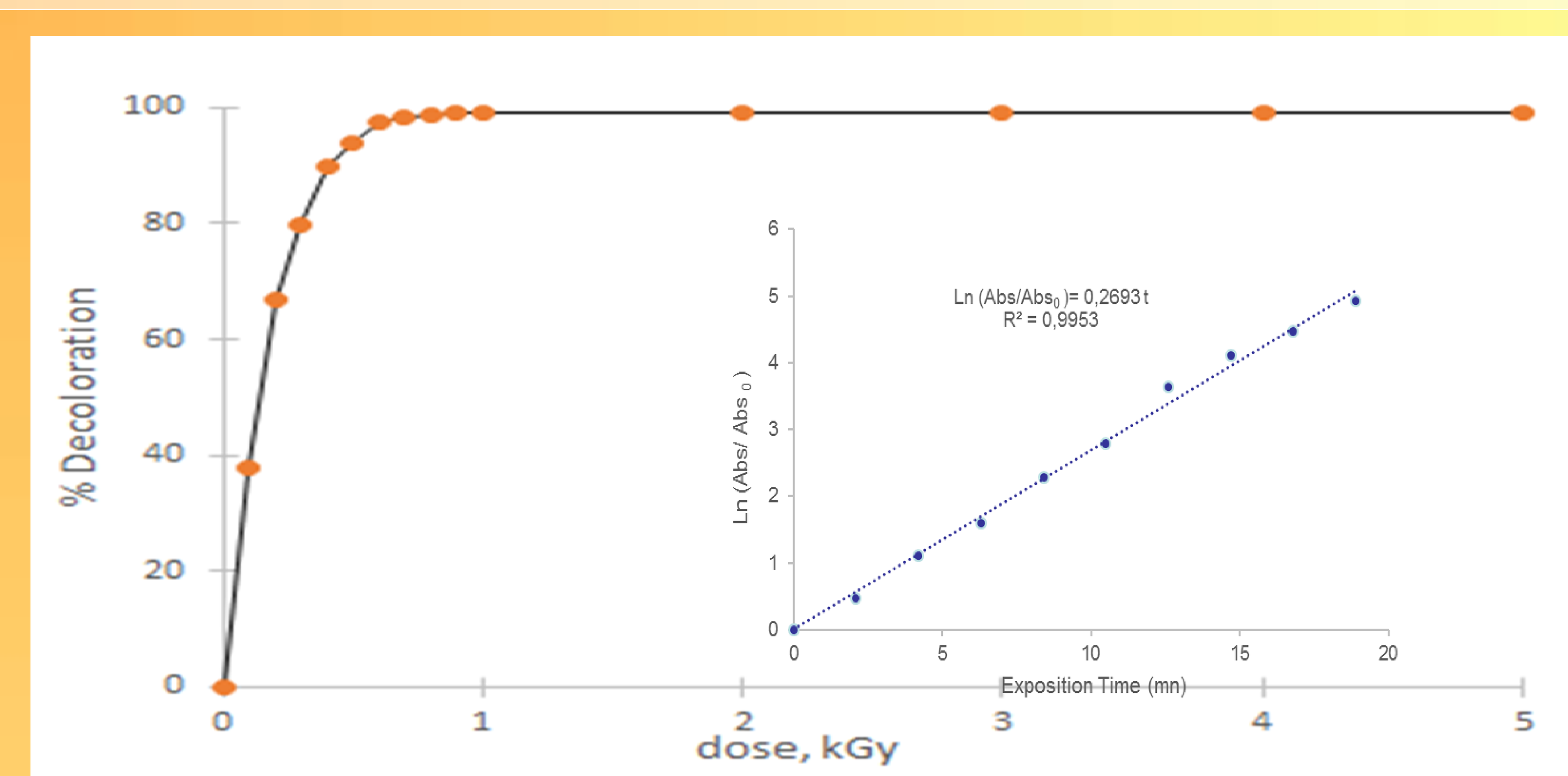

Fig. 4. *% decoloration of aqueous solution of IC (150 mg/L) at different doses*

A linear variation indicating a pseudo first order degradation of indigo carmine with ***K_{app}= 0.269 min^{-1}***

5. COD Analysis

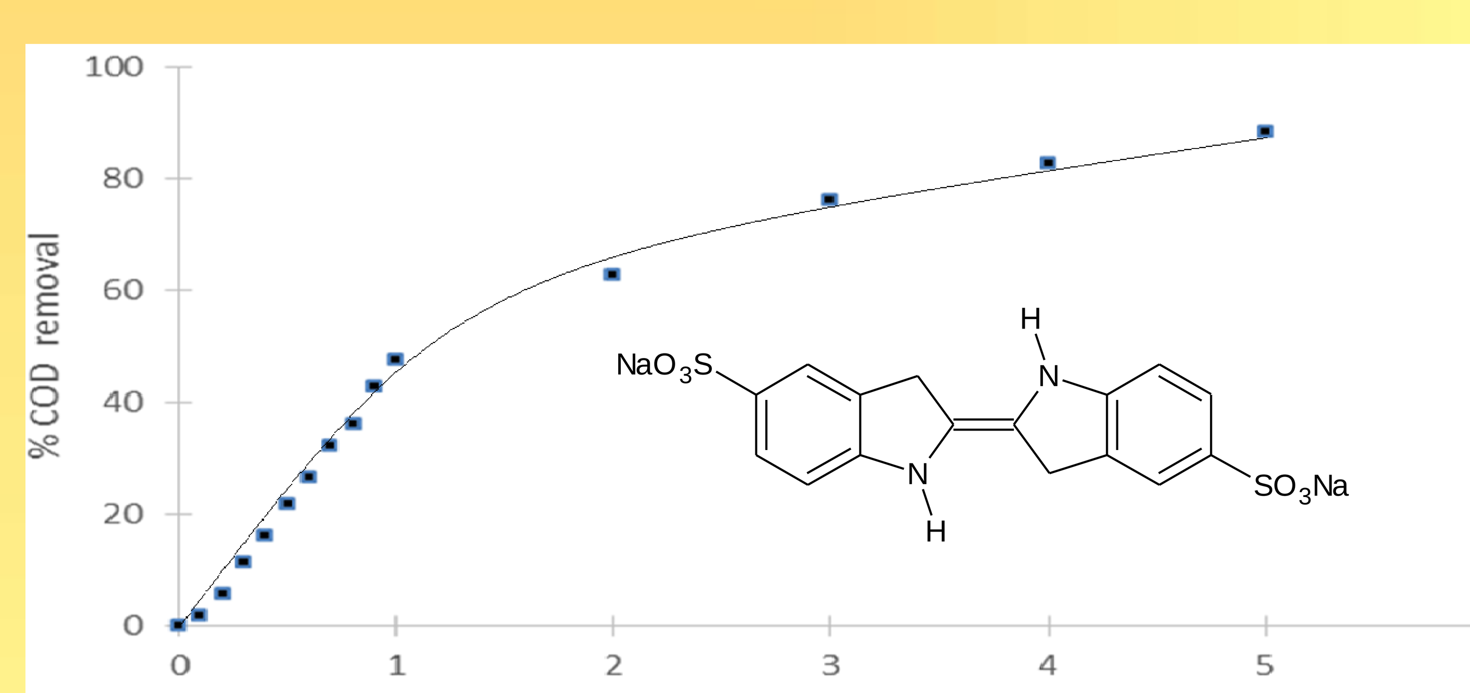

Fig. 5. *% COD removal of aqueous solution of IC (150 mg /L) at different doses.*

The COD reduction for the dye solutions was 95% at 5 kGy

In conclusion, radiation processing has been considered as a promising process for the treatment of textile dye indigo carmine.