Unraveling the Plasma–Photocatalysis Process: Coumarin Degradation Using a Modified Fountain DBD System

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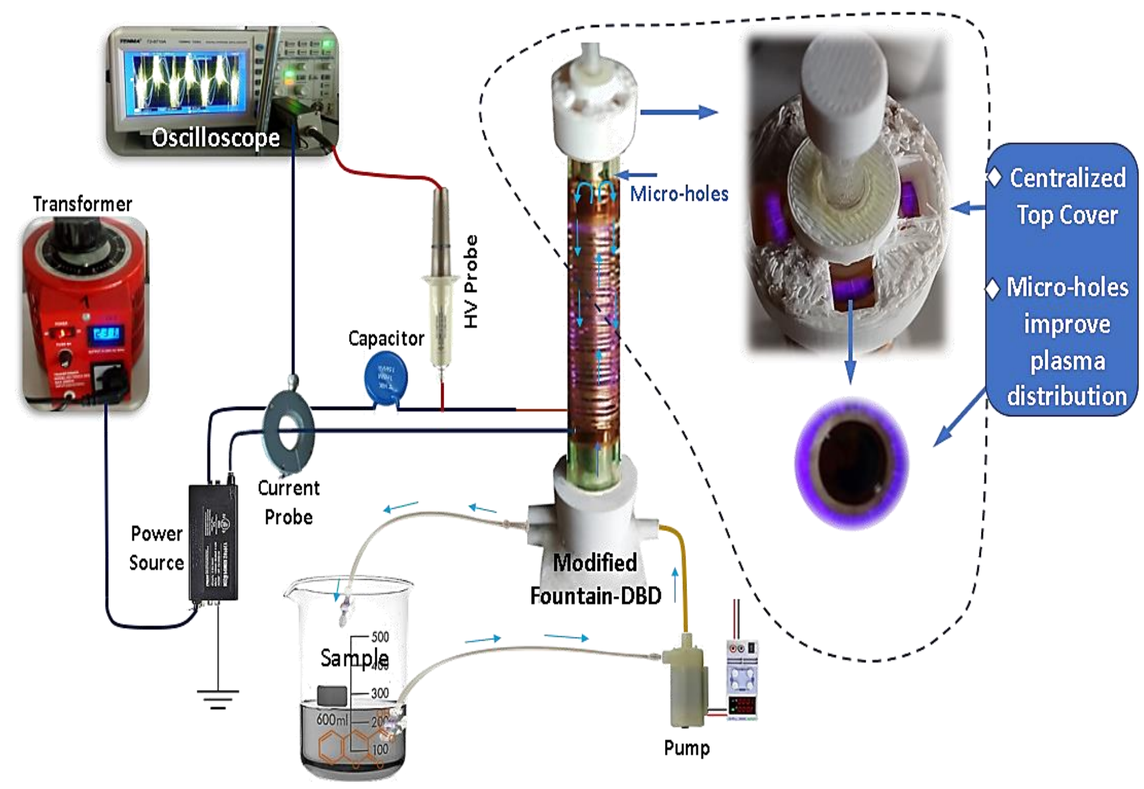
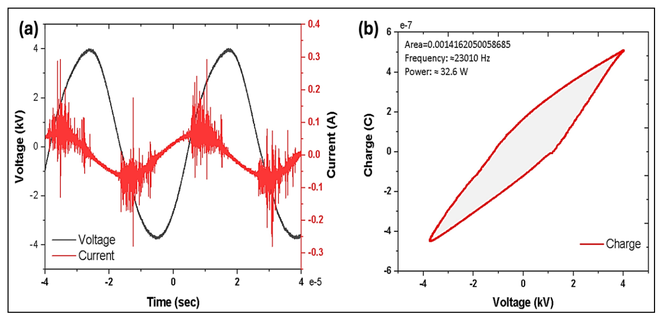
Abstract

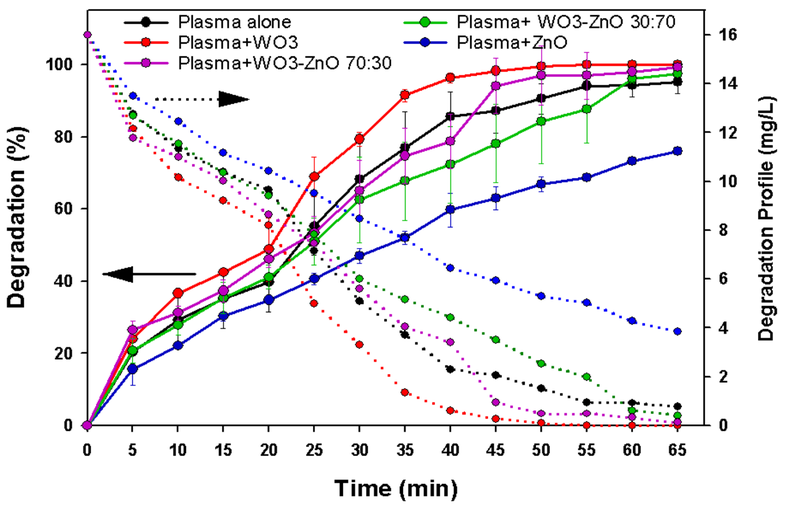
Coumarin is widely used in cosmetics and pharmaceuticals, has emerged as a persistent and potentially toxic contaminant. This study investigates coumarin degradation using a modified fountain dielectric barrier discharge (MF-DBD) plasma reactor, operated alone and in combination with WO_3, WO_3–ZnO, and ZnO catalysts. Under identical conditions (16 mg/L, atmospheric air pressure, 0–65 min), plasma treatment achieved 95% degradation, primarily via •OH-mediated oxidation. Incorporating catalysts significantly enhanced degradation kinetics and mineralization. WO_3 promoted reactive oxygen species (ROS) generation, while ZnO improved pH stability. The WO_3–ZnO composites exhibited composition-dependent synergy, achieving >97% removal efficiency, with Plasma + WO_3 showing the highest performance (99.9% degradation, 84% TOC reduction). The results highlight the strong plasma–catalyst coupling effect and demonstrate MF-DBD plasma systems as efficient, green technologies for treating recalcitrant organic pollutants.

Experimental Set-Up

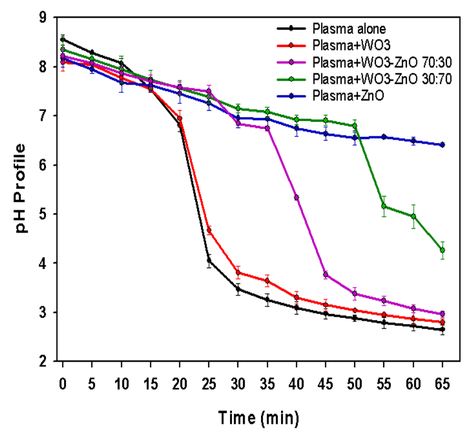


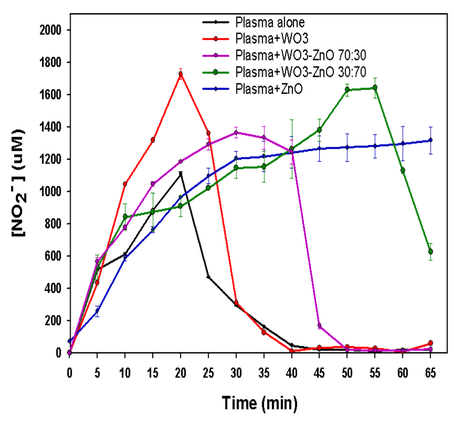
Results

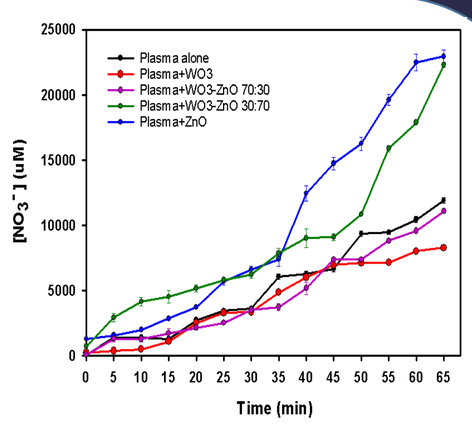


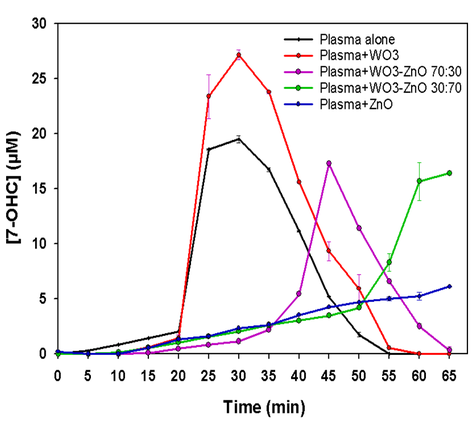


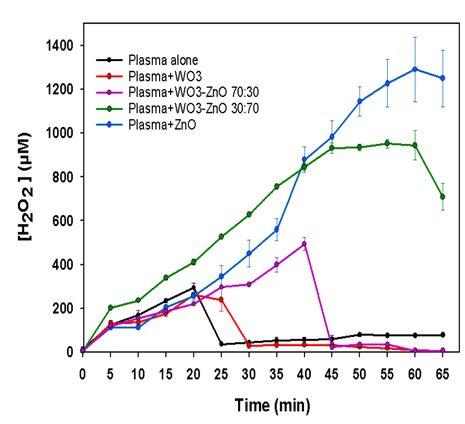
Plasma Species

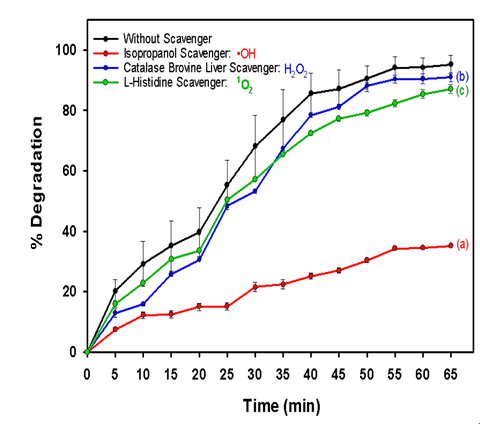




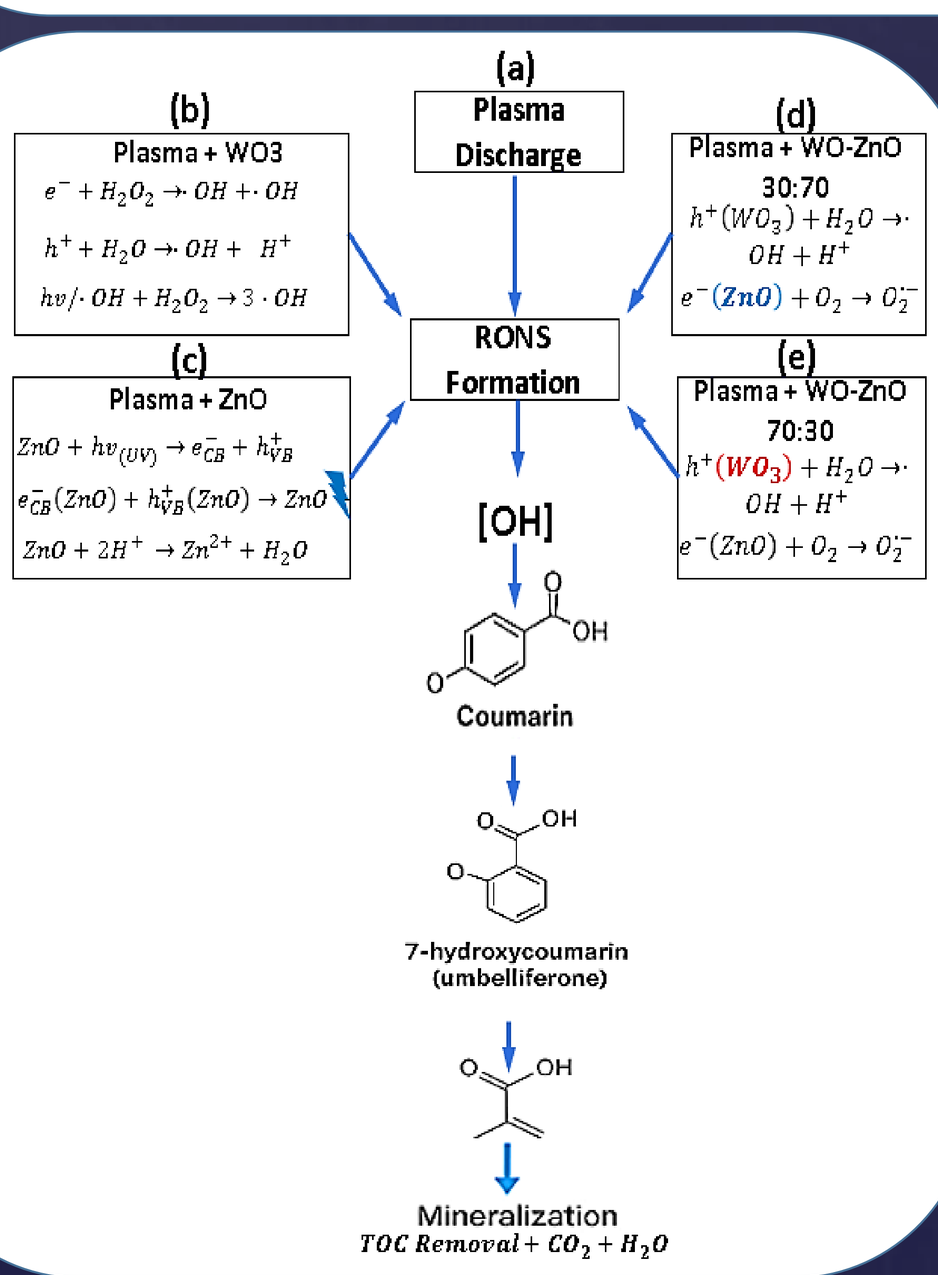








Proposed Pathway



Conclusion

- The **MF-DBD plasma system** effectively degraded coumarin under atmospheric conditions without additional oxidants.
- **Catalyst coupling** significantly enhanced degradation and mineralization through improved generation and utilization of reactive oxygen species.
- Among the tested systems, **Plasma + WO_3** exhibited the **highest efficiency** (99.9% degradation, 84% TOC removal).
- The findings demonstrate that **MF-DBD plasma–catalyst systems** are a **promising, sustainable technology** for advanced treatment of persistent organic pollutants in water.

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