IOCPC
2026
Conference

The 1st International Online Conference on Photochemistry
8–9 April 2026 | Online

MDPI

Di-Nuclear Water-Soluble Oxovanadium (V) Schiff Base Complexes: Electrochemical Properties, Catalytic Oxidation, and Photovoltaic Applications

RAHHOU Abd Elaziz [1], HASNAOUI Ali [2], ROCHDI Nabil [1], AIT ALI Mustapha [2]

[1] IMED-Lab, Faculty of Sciences and Techniques, Cadi Ayyad University, Bd Abdelkrim Al Khattabi, BP 549, 40000, Marrakech, Morocco.
[2] Molecular Chemistry Laboratory, Faculty of Sciences Semlalia, Cadi Ayyad University, BP 2390 Bd My Abdellah, 40000 Marrakech, Morocco.

INTRODUCTION & AIM

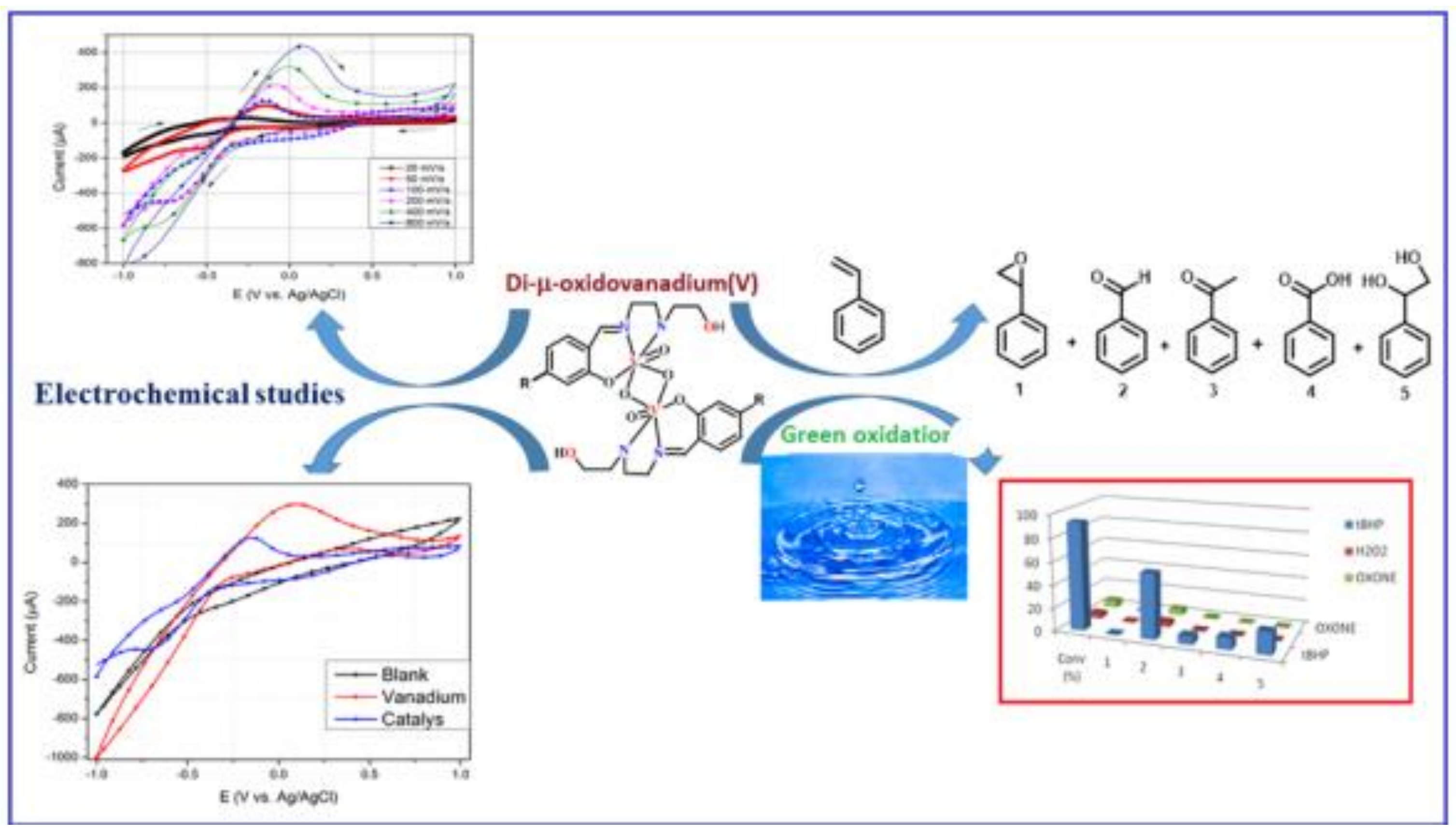
Metal–Schiff base complexes have attracted increasing interest due to their remarkable structural versatility, high stability, and significant catalytic potential in environmentally friendly transformations **[1,2]**. Their ability to coordinate with various metal ions through tunable donor atoms allows fine control over their electronic and steric properties, making them highly attractive in catalysis. In particular, the incorporation of functional groups can enhance solubility, recyclability, and catalytic efficiency in green media.

Vanadium, a biocompatible transition metal, is well known for its versatile redox properties and ability to access multiple oxidation states, which makes it especially suitable for oxidation reactions **[3,4]**. Among these, the oxidation of olefins represents a key transformation in organic synthesis, leading to valuable intermediates such as epoxides and diols widely used in pharmaceuticals and fine chemicals.

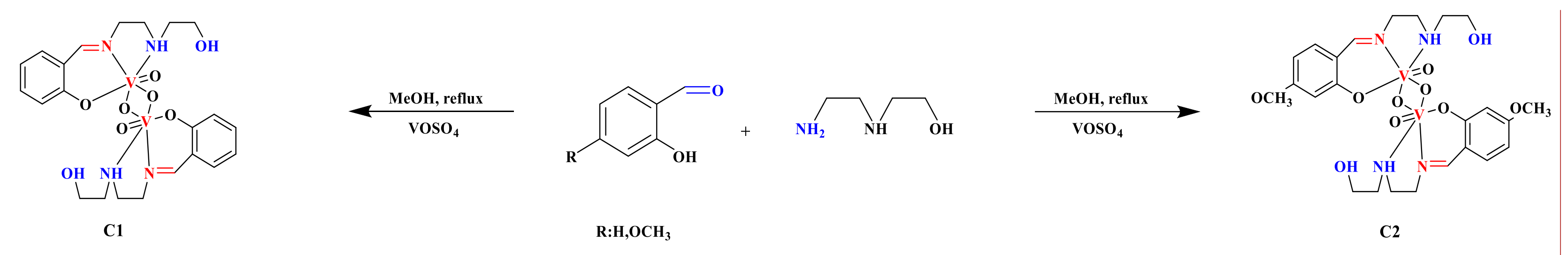
Despite these advantages, the use of water-soluble vanadium complexes as green catalysts in aqueous media remains relatively underexplored **[5,6]**. Developing such systems is particularly important in the context of sustainable chemistry, as water is a non-toxic, inexpensive, and environmentally benign solvent. Therefore, designing efficient and reusable water-soluble vanadium-based catalysts represents a promising strategy for advancing green oxidation processes.

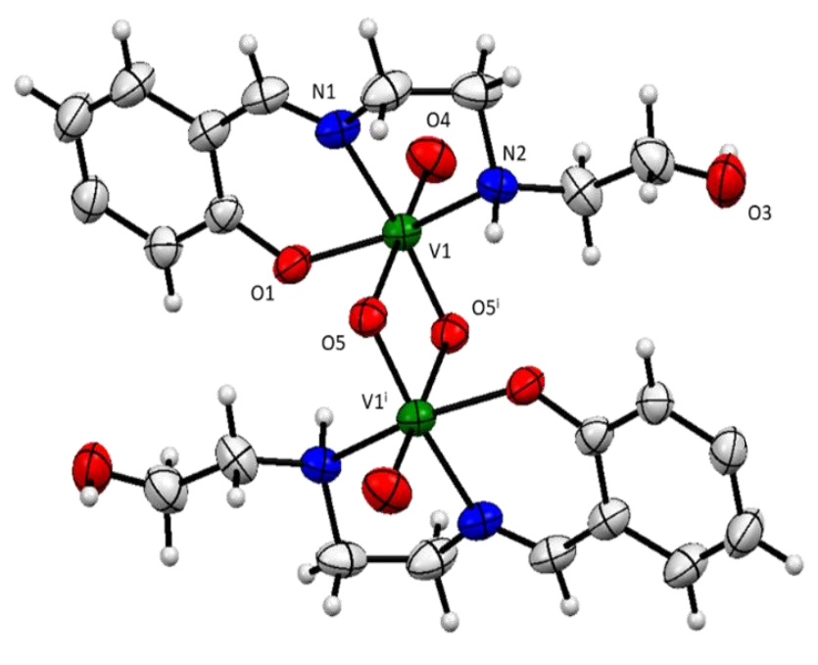
This work aims to synthesize and characterize two water-soluble dinuclear oxovanadium complexes, investigate their electrochemical behavior, and evaluate their efficiency as catalysts for the oxidation of olefins under environmentally friendly conditions.

METHOD



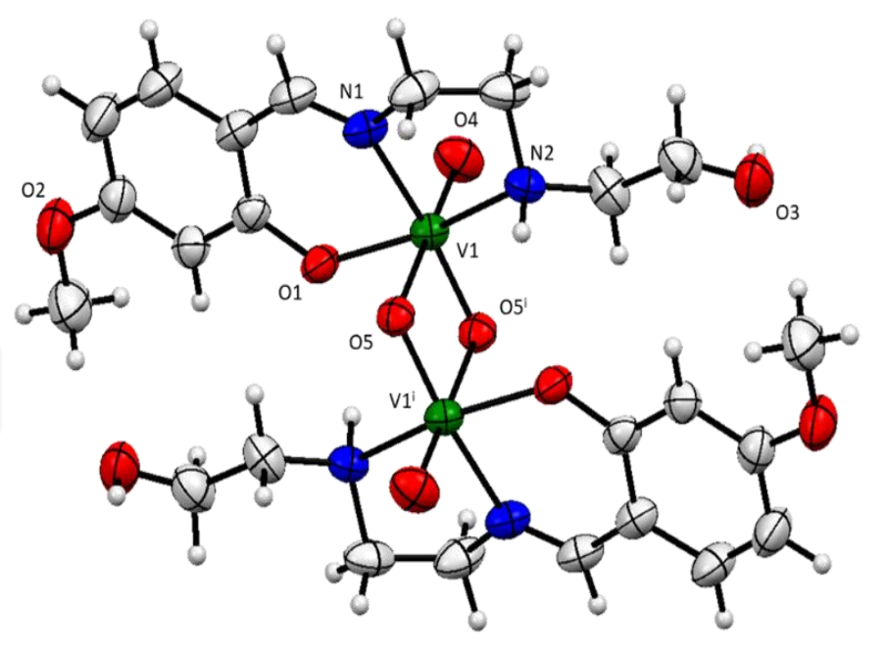
RESULTS & DISCUSSION



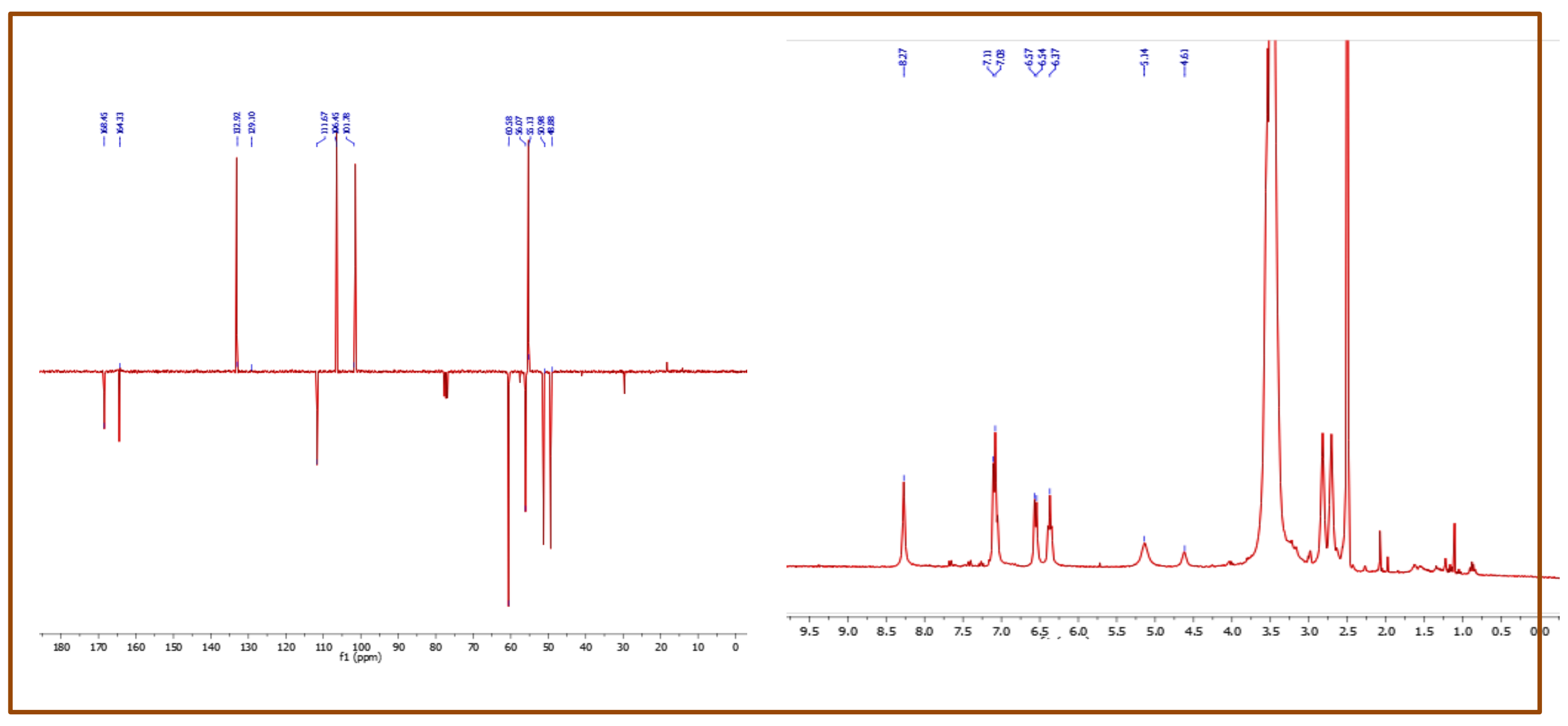


Complex C1

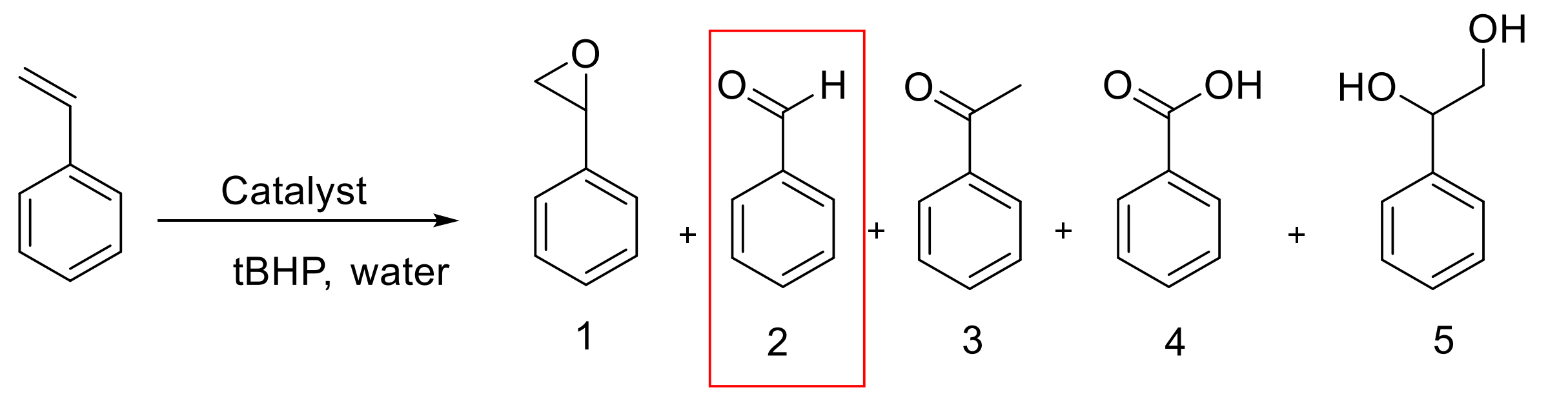
The yields of the two complexes are average



Complex C2



^{1}H and ^{13}C NMR Spectroscopy of C1

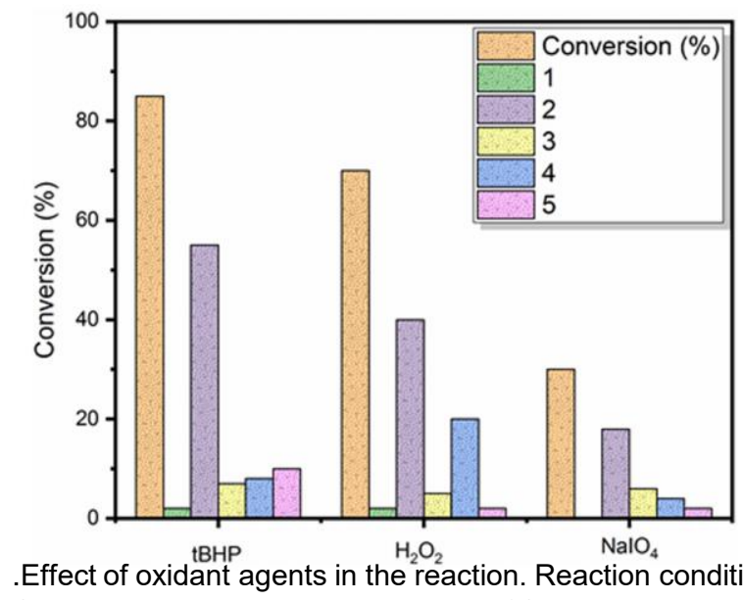


catalytic oxidation

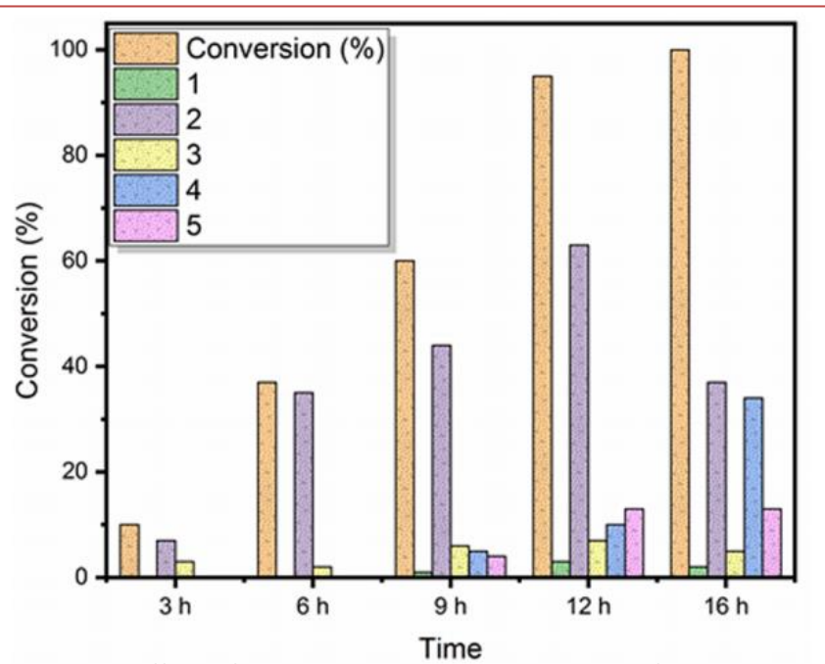
Effect of the catalyst and the catalyst amount.

Entry	Catalyst	Amount of Catalyst (g)	Conversion (%)	Yield (%)				
				1	2	3	4	5
1	Without	0	20	None	12	8	None	None
2	$VOSO_4$	0.002	40	trace	18	16	6	None
3	C1	0.076	100	trace	50	3	25	3
4	C2	0.079	100	trace	48	3	23	2
5	C1	0.038	85	trace	55	5	8	10
6	C1	0.025	76	trace	45	6	4	5
7	C1	0.019	50	trace	39	5	3	4

Reaction conditions: tBHP/Styrene: 3 eq, temperature: 40 °C, water: 5 mL,



.Effect of oxidant agents in the reaction. Reaction conditions: complex C1: 0.038 g, styrene: temperature: 40 °C, reaction time: 12 h, water: 5 mL,



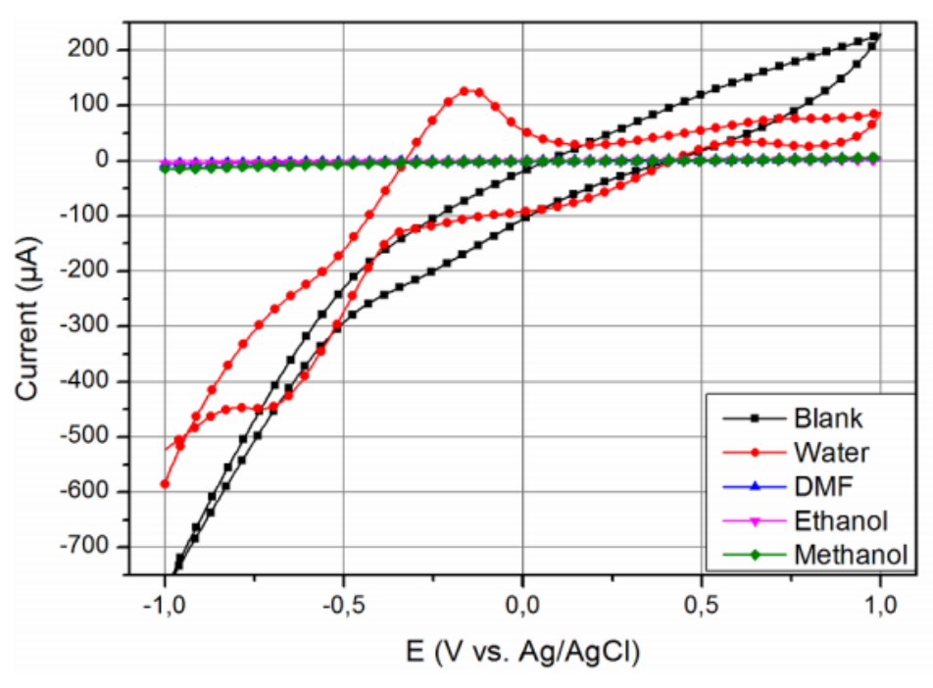
Effect of reaction time on the oxidation of styrene. Reaction conditions:
complexC1: 0.038 g, tBHP/Styrene: 3 eq, temperature: 50 °C, water: 5 mL.

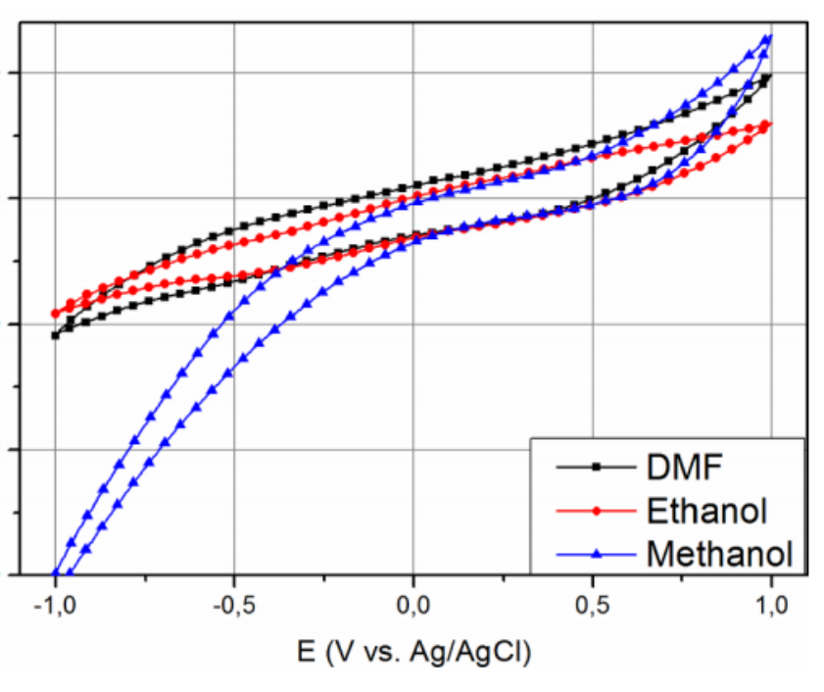
Recycling of the catalyst.

Cycle	Conversion %	yield %				
		1	2	3	4	5
Fresh	95	trace	63	7	10	13
1	93	trace	61	6	7	10
2	94	trace	60	5	4	8
3	90	trace	59	3	2	7
4	70	trace	53	5	trace	4

Reaction conditions: complex C1: 0.038 g, tBHP/Styrene: 3 eq, styrene: 1.32 mmol, temperature: 50 °C, water: 5 mL, reaction time: 12 h

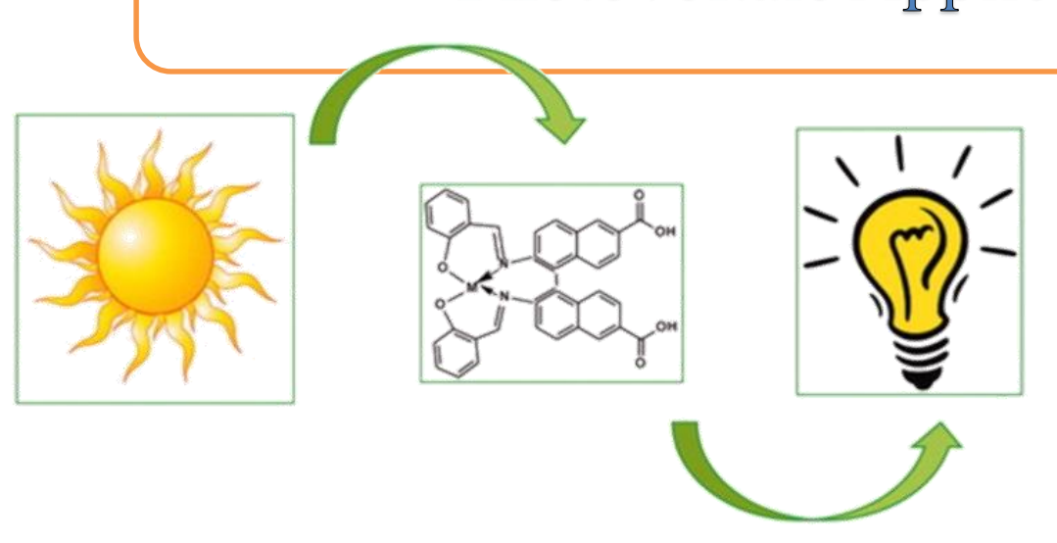
Photovoltaic Applications (Overview)



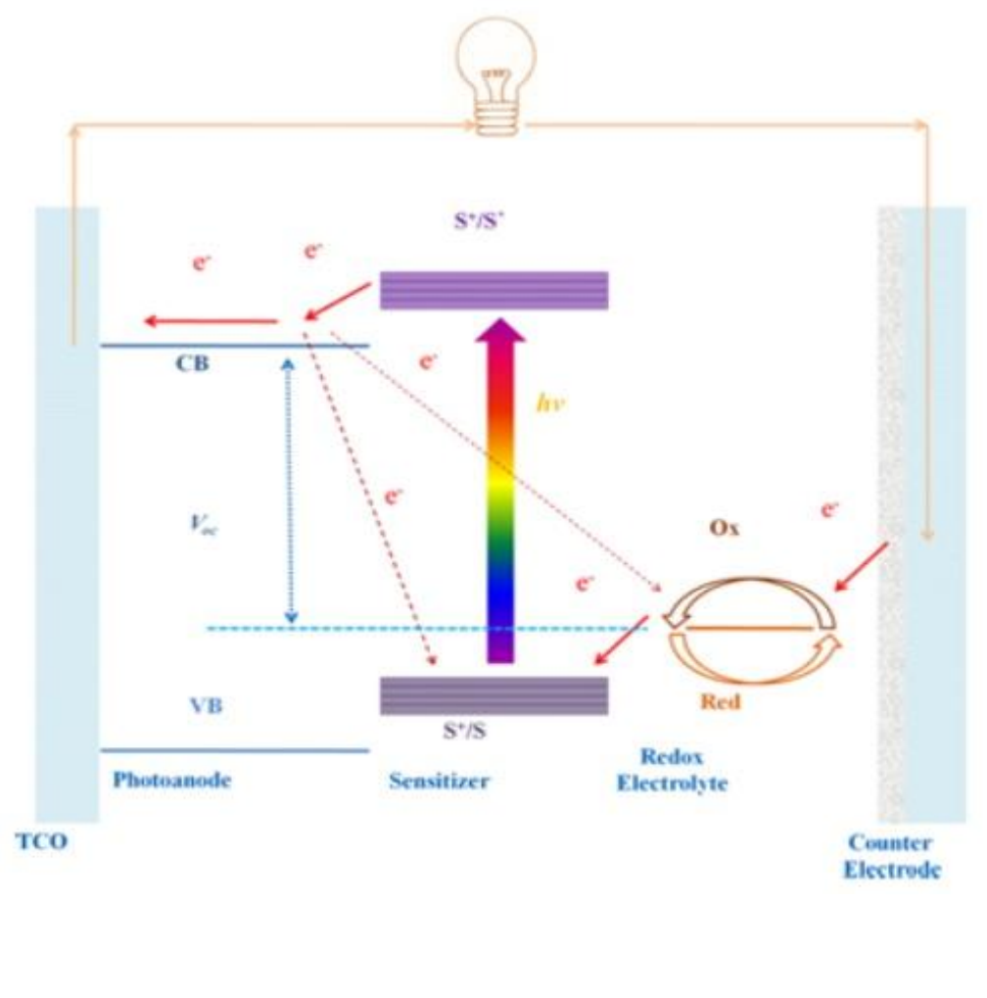


the electrochemical properties were conducted in different media such as water, DMF, Ethanol and Methanol with a scan rate of 100 mV/s. It is clear from the CV that complexC1dissolved in water shows the electrochemical reactions related to the oxidation and reduction pics. Polarization curves of the complex in water display cathodic and anodic peaks respectively at about −0.726 V (Ic) and −0.154 V(Ia), complex does not present any electrochemical activity in DMF, Ethanol and methanol solutions

Photovoltaic Applications (Overview)



Operating principle of a dye-sensitized solar cell (DSSC). Schematic diagram of the electron-transfer processes occurring at the interfaces between each component in a DSSC **[7]** .



CONCLUSIONS

Two dinuclear water-soluble oxovanadium(V) complexes were synthesized and evaluated for their catalytic activity in the oxidation of olefins. The electrochemical behavior of these oxovanadium species was also investigated. An irreversible redox process was observed for the dioxovanadium complexes, which can be attributed to the instability of the reduced species in aqueous medium. Furthermore, both the vanadium salt and the corresponding complexes exhibited an irreversible one-electron transfer process, consistent with an ErCi mechanism.

The catalytic oxidation of styrene was carried out using these two water-soluble Schiff base complexes in the presence of tert-butyl hydroperoxide (tBHP) as the oxidant and water as the solvent. Both catalysts demonstrated high conversion rates and good selectivity toward benzaldehyde formation. The optimized reaction conditions highlight several advantages, including the use of a non-toxic solvent, a relatively benign metal center, and a straightforward procedure under mild conditions.

FUTURE WORK/ REFERENCES/ACKNOWLEDGMENT

Future work will focus on exploring the potential application of these oxovanadium complexes in photovoltaic systems, with particular attention to their optical and electronic properties and their suitability for integration into light-harvesting devices.

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