RESEARCH ARTICLE

GREEN AND EFFICIENT OXIDATION OF AROMATIC SECONDARY ALCOHOLS VIA POLYMER-BOUND REAGENTS

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ABSTRACT:

This investigation aims to highlight the key applications of these reagents in green and efficient synthetic chemistry, also presenting a complete impression of the polymeric reagents recently employed in organic synthesis. [1-3]. in recent years, polymer-supported reagents have established extensive use across various applications. These talented materials are now generally employed in the organic synthesis laboratories of pharmaceutical and agrochemical industries. Researchers normally use them to generate arrays of small organic molecules for screening.

Chemical kinetics, a dedicated branch of chemistry, focuses on the inspection of reaction rates. A widespread study of chemical kinetics, in combination with other non-kinetic studies, allows for a systematic understanding of reaction mechanisms. Reactions span a wide range of speeds; some occur speedily, within fractions of a second, while others progress exceptionally slowly, as exemplified by the gradual rusting of iron. Between these extremes, there are reactions that elucidate over a reasonable timeframe, making them open to systematic study through suitable methods.

Many researchers have made significant contributions to the field of chemical kinetics. Innovative work by scientists like Ludwig Ferdinand Wilhelmy, Wilhelm Ostwald, C. F. Wenzel, Louis Jacques Thenard, Pierre Eugene Marcellin Berthelot, Leon Pean de Saint-Gilles, Peter Waage, and Harcourt helped build the foundation of our understanding of how chemical reactions happen and how their rates can be calculated.[4-5].

KEYWORDS: *Polymeric reagent; Solid-supported reagent, oxidation, Alcohols.*

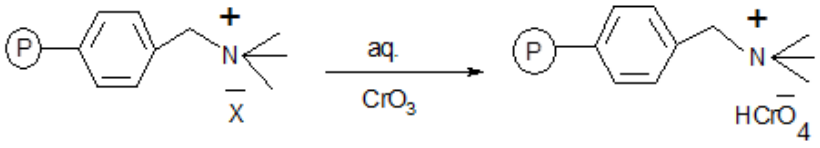
1. INTRODUCTION

The use of polymer-supported species in both syntheses and separations is progressively increasing and the applications in industry maintain to grow [6] Medicinal chemists in the pharmaceutical industry now regularly employ polymer-supported reagents to prepare ensembles of small organic molecules [7]. Using polymeric materials as supports, solid supported reagents or scavengers have a huge influence in organic synthesis, work-up, and purification of the products.

In anticipation of *Merrifield* introduced the idea of solid phase peptide synthesis in 1963 all chemistry was performed in solution-phase. In 1962, *Merrifield* utilized a functionalized and nitrated styrene-divinylbenzene co-polymer for synthesizing a tetra peptide [8]. This polymer was reacted with an amino acid with its amino group protected by a carbobenzoxy group. For deprotecting the amino group of the product, utilized a HBr=HO*Ac* mixture. For chain extension, the product was reacted with another carbobenzoxy-protected amino acid and at the end of the reaction; the polymer linkage was cleaved by saponification. The manipulations required for the synthesis of a polypeptide chain consist simply of pumping the proper solvents or reagents into and out of the vessel containing the polymer in the proper sequence and timing. It was clear to *Merrifield* that the simplicity of the steps involved in this process could be automated. The construction an apparatus which performed all these operations automatically [9-14]. The ease of solid phase synthesis (SPS) compared with the labor and time to produce a tetra peptide by conventional solution approaches was sufficient to attract considerable attention of the scientists.

II. PREPARATION OF SUPPORTED OXIDIZING AGENT

The supported oxidizing agent was prepared by reported method. The Chromate forms of Tulsion A-23 containing a quaternary ammonium group [10 x 10^{-3} kg] was stirred with a saturated solution of periodates [5 x 10^{-3} dm^3] in water [30 x10^{-3} dm^3] for 30 min at room temperature using a magnetic stirrer. The Chromate ion was readily displaced and Chromate form of resin was obtained in 60 min. The resin was successively rinsed with water, acetone and THF and finally dried in vaccum at 323 K for 7h. The dried form of the resin was stored and used throughout the kinetic study.



[X = Cl] **Polymer supported oxidizing agent**

III. DETERMINATION OF CAPACITY OF POLYMERIC REAGENT

The capacity of Chromate form of Tulsion A-23 polymeric reagents was resolute by iodometrically. The capacity of the chromate form of resin were 2.20 and 2.50 eq/L and used for kinetic study throughout work. The loading was also determined by elemental nitrogen analysis and were found to be 1.50 and 1.89 eq/L.

IV. METHOD OF KINETICS

The reaction mixture for the kinetic run was prepared by mixing alcohol, oxidant and solvent. The reaction was carried out either constant stirring using magnetic stirrer and at a constant

temperature 318 ±1 K. At different time interval, the reaction mixture was withdrawn using a micropipette. The aliquot thus withdrawn was taken in a stoppered test tube containing 5 x 10^{-3} dm^3 of 1, 4-dioxane and subjected to spectral analysis. The absorbance of the product formed was measured using SL 159 UV-visible spectrophotometer. Duplicate kinetic runs showed that the rate constants were reproducible to within ±1 %.

V. RESULTS AND DISCUSSION [18-19].

The Influence of Concentration of Alcohol Change on Reaction rate

Table 1: Study rate of reaction for change in concentration of alcohol

Alcohols	50 mg	60 mg	70 mg	80 mg
	$k \times 10^{-4}$ min^{-1}			
1-Phenylethanol	1.30	1.60	1.70	2.00
4-Methylphenylethanol	1.33	1.66	2.00	1.32
4-Methoxyphenylethanol	1.49	1.40	1.78	1.67
4-Flurophenylethanol	1.66	2.97	2.13	2.35

The influence of Polymeric Reagent Change on Reaction rate

Table 2: Study rate of reaction for change in concentration of polymeric reagent

Alcohols	50 mg	60 mg	70 mg	80 mg
	$k \times 10^{-4}$ min^{-1}			
1-Phenylethanol	1.35	1.47	2.75	2.85
4-Methylphenylethanol	1.69	1.72	2.55	2.70
4-Methoxyphenylethanol	1.74	2.20	2.76	2.83
4-Flurophenylethanol	2.10	2.30	2.79	2.93

It is evident from the information from above table that,

1. The graphically calculated 'k' values at different time intervals remain nearly constant.
2. The Absorbance versus time plots consistently exhibit linear trends passing through the origin.
3. The average 'k' value, when considering all kinetic runs with varying polymeric reagent weights for each type of alcohol, also remains constant.

The influence of Concentration of Solvent on Reaction rate

Table 3: Study of rate of solvent change on reaction Rate

Alcohols	Dielectric Constant	C_6H_{12}	CCl_4	1,4 -Dioxane	$CHCl_3$
		$k \times 10^{-4}$ min^{-1}			
1-Phenylethanol	2.2	1.35	1.54	2.08	2.10
4-Methylphenylethanol	2.4	2.06	1.66	2.15	1.78
4-Methoxyphenylethanol	2.5	1.43	1.77	2.30	1.89
4-Flurophenylethanol	4.1	1.49	2.15	2.25	2.30

The Influence of Change in Temperature on Reaction Rate

The activation energy (Ea) analysis reveals a different trend: the activation energy for para-substituted 1-Phenyl ethanol follows a specific order, indicating.

1-Phenylethanol >4-Methylphenylethanol >4-Methoxyphenylethanol > 4-Florophenylethanol

Table 4: The Influence of temperature Change on reaction rate

Alcohols	40°C	45°C	50°C	55°C
	$k \times 10^{-4}$ min^{-1}			
1-Phenylethanol	1.65	1.78	3.15	3.26
4-Methylphenylethanol	1.75	1.79	2.05	2.58
4-Methoxyphenylethanol	1.86	1.80	1.87	2.66
4-Flurophenylethanol	2.18	2.33	2.55	3.69

Table 5: Temperature Coefficient of P-substituted alcohols

Sr. No.	Alcohols	Temperature coefficient
I	1-Phenylethanol	1.46
II	4-Methylphenylethanol	1.56
III	4-Methoxyphenylethanol	1.78
IV	4-Flurophenylethanol	1.55

The reasonable values of activation enthalpy ($\Delta H^{\#}$) and activation entropy ($\Delta S^{\#}$) observed in this study provide valuable insights into the nature of electron transfer processes involved. These values fall within a range that is typically positive for reactions involving electron transfers

Table 6: Study of Energy of activation of P-Substituted alcohols

Sr. No.	Alcohols	E_a Kcal mol^{-1}
I	1-Phenylethanol	12.43
II	4-Methylphenylethanol	12.68
III	4-Methoxyphenylethanol	12.90
IV	4-Flurophenylethanol	11.34

Frequency factor

The combination of a low frequency factor (A) and negative activation entropy further reinforces our earlier assessment of the reaction. The consistency in the free energy of activation ($\Delta G^{\#}$) across all oxidation reactions is a noteworthy observation. This consistency strongly indicates that a similar mechanism likely governs all of these reactions. The near-identical $\Delta G^{\#}$ values imply that, despite potential variations in reactants or reaction conditions, the overall energy barrier that must be overcome to reach the transition state remains remarkably constant. This suggests a common set of chemical pathways and interactions, regardless of the specific reactants involved.

Table 7: Frequency factor for P-Substituted alcohols

Sr. No.	Alcohols	Frequency Factor × 10^{-5} min^{1}
I	1-Phenylethanol	3.99
II	4-Methylphenylethanol	5.20
III	4-Methoxyphenylethanol	6.25
IV	4-Flurophenylethanol	3.13

Table 8: Enthalpy of activation of P-substituted alcohols

Sr. No.	Alcohols	$\Delta H^{\#}$ Kcal mol^{-1}
I	1-Phenylethanol	6.521
II	4-Methylphenylethanol	5.734
III	4-Methoxyphenylethanol	9.556
IV	4-Flurophenylethanol	6.445

The negative values of the activation entropy ($\Delta S^{\#}$) in each case serve as compelling evidence supporting the assertion that the rate-determining step entails the association of molecules, accompanied by a restriction in their freedom of motion. This implies that the transition state exhibits a higher degree of orderliness compared to the initial reactant molecules.

Table 9: Entropy of activation for P-Substituted alcohols

Sr. No.	Alcohols	$\Delta S^{\#}$ e.u
I	1-Phenylethanol	-54.59
II	4-Methylphenylethanol	-52.60
III	4-Methoxyphenylethanol	-46.57
IV	4-Flurophenylethanol	-54.80

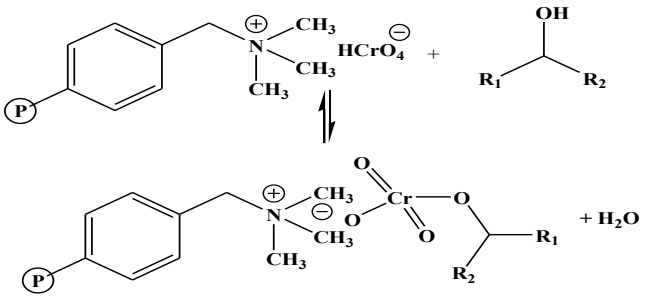
Table 10: Free energy of activation of P-Substituted alcohols

Sr. No.	Alcohols	$\Delta G^{\#}$ Kcal.mol^{-1}
I	1-Phenylethanol	24.20
II	4-Methylphenylethanol	24.69
III	4-Methoxyphenylethanol	24.58
IV	4-Flurophenylethanol	24.48

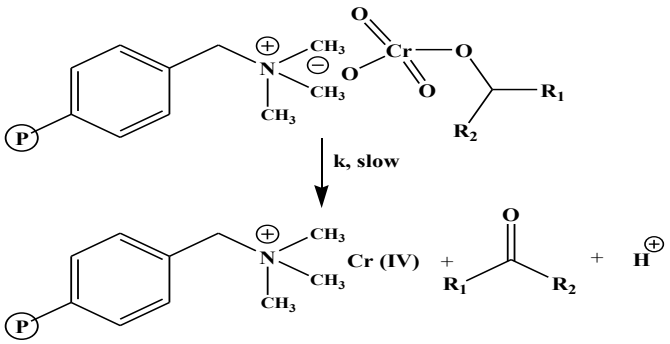
Based on the obtained experimental results, which indicate a zero-order reaction for the oxidation of substituted 1-Phenylethanol, a reasonable mechanistic proposal can be put forth.

Scheme of Mechanism

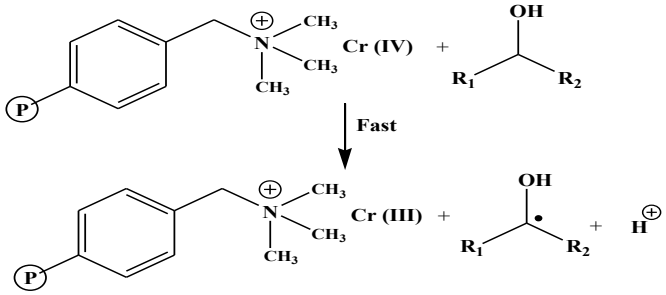
1] The preliminary step in the mechanism involves the formation of an ester



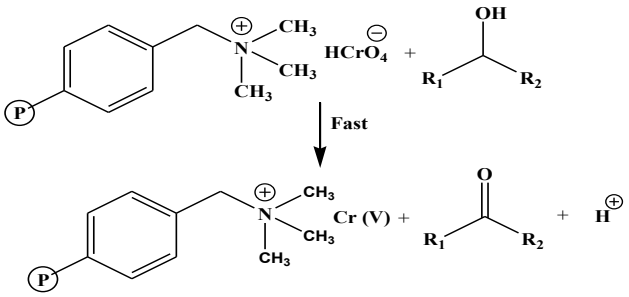
2] In the subsequent step, the formed ester will undergo decomposition, yielding a ketone. This process leads to the formation of the intermediate chromium (IV) in the second, which is also the slower, step.



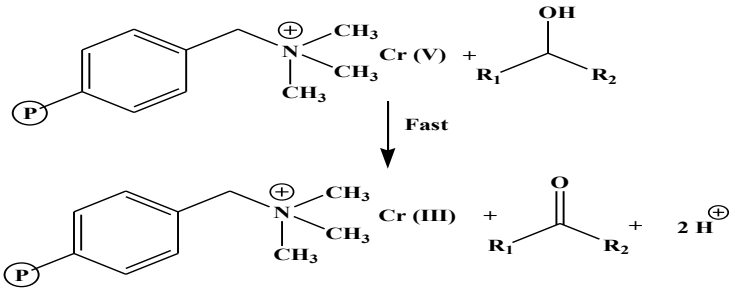
3] The intermediate Chromium (IV) undergoes a reaction with another alcohol, resulting in the formation of free radical. This free radical formation was substantiated by observing the polymerization of acrylonitrile within the reaction mixture as well as by ESR spectrum.



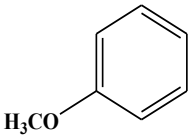
4] The free radical will counter with a second oxidant position in the polymeric reagent in a fast step leading to the creation of chromium (V).



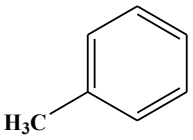
5] Transition chromium (V) in the last step reacts with alcohol to produce ketone. The test for formation of chromium (IV) and chromium (V) by their characteristic induced oxidation of iodine and manganese (II) were not successful, probably due to heterogeneity of the reaction mixture.



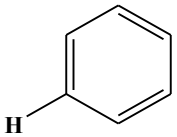
Where R_2 = -CH_3 and R_1 =



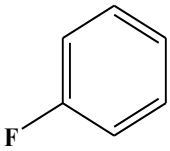
4-Methoxyacetophenone



4-Methylacetophenone



Acetophenone



4-Fluoroacetophenone

In compliance with above Scheme, we expect a second-order rate law due to the initial solid-phase ester formation step. supercilious this equilibrium does not considerably influence the overall reaction rate, we examine a zero-order dependence on the rate constant 'k' for the subsequent slower step, where in the reaction corresponding ketone product is generated.

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