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Exploring The Fermentation Potential of Metal Complexes With Novel Benzothiazolyl Hydrazones : A Study in Fe (III) And Co(II) Coordination

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ABSTRACT

In the realm of fermentation chemistry, the utilization of metal complexes as catalysts has garnered significant attention due to their potential to enhance reaction efficiency and selectivity. This research investigates the fermentation reaction mediated by metal complexes comprising Fe(III) and Co(II) ions in conjunction with a novel ligand, 2-(2'-hydroxy-3'-methoxy phenyl)-4-bromo-6 methyl benzothiazolyl hydrazones. The synthesis and characterization of these complexes were meticulously carried out using spectroscopic and analytical techniques. Subsequently, their catalytic activity in fermentative processes was explored, focusing on their impact on reaction kinetics, product yield, and selectivity. Through a series of experiments, the catalytic performance of these metal complexes was evaluated and compared against traditional catalysts. The results shed light on the potential of these metal-ligand complexes as efficient catalysts in fermentation reactions, thereby paving the way for their broader applications in organic synthesis and biotechnology.

Keywords :- Ligand, metal ion, metal ion chelates, Saccharomyces Cerevisieae.

I. INTRODUCTION

Fermentation processes represent an integral aspect of biotechnological industries, serving as a cornerstone for the production of various valuable compounds ranging from pharmaceuticals to biofuels. The optimization and enhancement of fermentation reactions have been subjects of intense research focus, with a particular interest in exploring novel catalysts to improve reaction efficiency and selectivity. Metal complexes, with their diverse catalytic properties, have emerged as promising candidates for facilitating and modulating fermentation pathways.

Transition metal ions, such as iron (Fe) and cobalt (Co), have garnered significant attention in catalytic applications due to their ability to undergo redox reactions and coordinate with various ligands. Among the ligands explored, benzothiazolyl hydrazones have emerged as intriguing candidates for metal complexation. These ligands possess unique structural features, making them suitable for coordinating with transition metal ions and forming stable complexes with distinct catalytic properties.

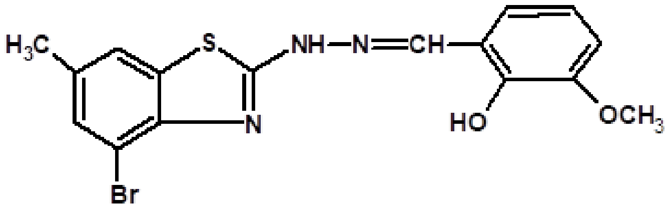
In this research paper, we explore the fermentation potential of metal complexes featuring novel benzothiazolyl hydrazones as ligands, with a specific focus on Fe(III) and Co(II) coordination. We aim to elucidate the coordination chemistry of these metal-ligand systems and investigate their catalytic activity in fermentation reactions. By employing a combination of synthetic chemistry, spectroscopic techniques, and fermentation assays, we seek to understand the mechanistic insights behind the catalytic role of these metal complexes in fermentation processes.

Our study builds upon previous research highlighting the versatility of metal complexes in catalysing biochemical transformations and optimizing fermentation conditions. We integrate concepts from coordination chemistry, enzymology, and fermentation engineering to provide a comprehensive analysis of the synergistic interactions between metal complexes and fermentation substrates.

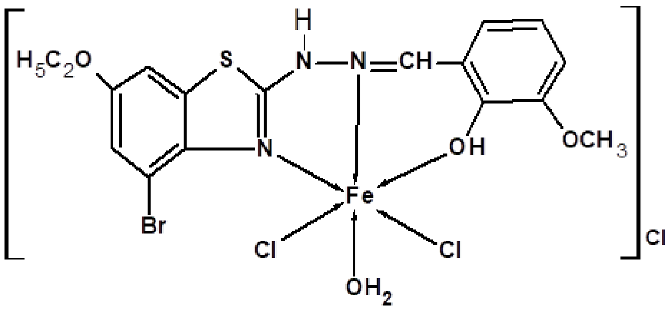
Through this research, we aim to contribute to the development of efficient and sustainable fermentation processes by harnessing the catalytic potential of metal complexes. By elucidating the fundamental principles governing metal-ligand interactions and their impact on fermentation kinetics and product yields, we envision the advancement of biotechnological applications in diverse industrial sectors.

II. MATERIAL AND METHODS

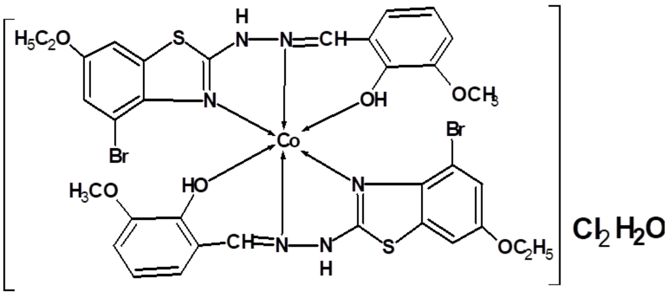
The ligand 2-(2'-hydroxy-3'methoxy phenyl)-4-bromo-6-methyl benzothiazolyl hydrazone It considered as HMPBMBTH and its metal chelates of Fe^{+3} $Co^{+2}$are used which are previously Reported. Structure of ligand and its metal chelates of Fe^{+3}, Co^{+2} are as.



2-(2'-hydroxy-3'methoxy phenyl)-4-bromo-6-methyl benzothiazolyl hydrazone.



structure of [Fe (HMPBEBTH) Cl_2H_2O] Cl



structure of [Co (HMPBEBTH $)_2$] Cl_2 H_2O

Microorganism- yeast used in the study was Saccharomyces Cerevisieae collected from local market. The culture was maintained on solid yeast medium.

Molasses. - The molasses were obtained from Local sugar industries Nanded.

Batch process is adopted in fermentation.

The % of reducing sugar is about 40% the molasses were diluted to prepare different concentration of sugars. The production medium is supplemented with nitrogen and Phosphate. The pH of medium was adjusted to 5.

Media composition.

KH2PO4- 0.1%

(NH4)2SO4 0.5%

$MgSO_4 \cdot 7H_2O$ 0.05%
Yeast extract 0.1%
pH 5

The ph of medium was adjusted by putting drop by drop dil. sulfuric acid.
The fermentation flask were arranged and they were labeled along with yeast catalyst. Metal salt and metal chelates were added. pH were adjusted. The fermentation flask were arranged and they were labelled along with yeast catalyst. Metal salt and metal chelates were added. pH were adjusted.

III.EXPERIMENTAL

To study the effect of the metal ions and metal chelates different experiment were carried out. All the fermentation flask were sterilized. All solution which are used for the experiment were also sterilised. 6 fermentation flask (sterilised) were arranged and they were labelled from 1 to 6. Fermentation flask no.1 is used as control, Fermentation flask no. 2 is used to study the effect of 2-(2'-hydroxy-3'-methoxy phenyl) -4-bromo-6-methyl benzothiazolyl hydrazones (HMPBMBTH) on fermentation process In conical flask no.3, 0.05 gm $Fe(CBMBTH)_2\ Cl_2.]Cl.H_2O$ and in conical flask no 4. $[Co\ (HMPBMBTH)_2]\ Cl_2.\ H_2O$ added. In flask no. 5, 6, metal chloride $FeCl_3$ $CoCl_2$ respectively added0.05 gm. Solution like 0.05 % $KHSO_4$, 0.5% $(NH_4)_2SO_4$, 0.05 % $MgSO_4\ 7H_2O$ and as mentioned above different metal ion were added . The pH of the experiment is adjusted by putting drop by drop dil. H_2SO_4. The fermentation reaction were carried out for 24 hours. In each fermentation flask 10 ml 1% molasses solution and media.

Estimation of biomass :- The quantity of biomass depends upon yeast growth takes place.
The dry biomass were measured by transferring the content of conical flask through the filter paper. The residue of biomass which is collected on the filter paper is dried by keeping it in oven at 100°C. The mass of biomass were recorded and it is given in the table.

Estimation of ethyl alcohol:-
Spectroscopic method is used to determine the alcohol generated in the fermentation process. Fermented wash were taken in distillation flask. 15 ml distillate were collected in the conical flask. 5 ml $K_2Cr_2O_7$ (0.1N) in 0.1N H_2SO_4 solution were added it is warmed at 60°C. The colour obtained. The optical density of solution were measured from standard graph. The ethanol generated during fermentation were determined. The experimental data is given in table.

Sr. No.	Flask No.	Compounds	%wt. of biomass	% Alcohol
1	1	Control	1.09	2.05
2	2	(HMPBMBTH)	1.10	2.10
3	3	$Fe(CBMBTH)_2\ Cl_2.]Cl.H_2O$	1.49	2.33
4	4	$[Co(HMPBMBTH)_2]\ Cl_2.\ H_2O$	1.37	2.39
5	5	$FeCl_3$	1.15	2.27
6	6	$CoCl_2$	1.13	2.19

The data provided presents the effects of various compounds on both the percentage by weight of biomass and the percentage of alcohol produced, as observed across different experimental conditions.
In the control flask (Flask No. 1), which represents the baseline scenario with no additional compounds, the percentage by weight of biomass was measured at 1.09%, yielding 2.05% alcohol production. This establishes a reference point for comparison against the experimental conditions.
Flasks No. 2 through 6 represent different compounds added to the biomass and their subsequent effects.
For instance, Flask No. 2 introduced (HMPBMBTH),

resulting in a marginal increase in both biomass weight percentage and alcohol production compared to the control.

However, notable changes are observed with specific compounds. Flask No. 3, featuring Fe(CBMBTH)$_2$ Cl$_2$.]Cl.H$_2$O, demonstrated a significant increase in both biomass weight percentage (1.49%) and alcohol production (2.33%) compared to the control. This suggests the compound's effectiveness in enhancing both parameters.

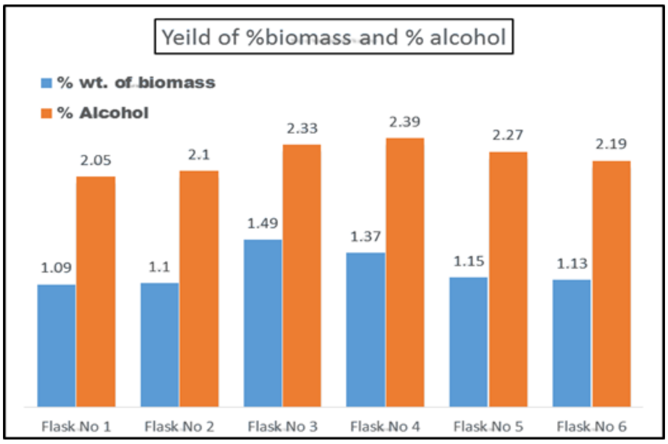
Similarly, Flask No. 4, containing [Co (HMPBMBTH)$_2$] Cl$_2$. H$_2$O, also showed an increase in both biomass weight percentage (1.37%) and alcohol production (2.39%), although slightly lower compared to Flask No. 3.

Comparing the effects of iron and cobalt compounds across Flasks No. 3, 4, 5, and 6 reveals distinct trends. Iron-containing compounds, such as Fe (CBMBTH)$_2$ Cl$_2$.]Cl.H$_2$O (Flask No. 3) and FeCl$_3$ (Flask No. 5), generally exhibited higher increases in biomass weight percentage compared to cobalt-containing compounds, including [Co (HMPBMBTH)$_2$] Cl$_2$. H$_2$O (Flask No. 4) and CoCl$_2$ (Flask No. 6). However, the cobalt-containing compounds tended to favour alcohol production to a greater extent.

Flasks No. 5 and 6 also displayed increases in both biomass weight percentage and alcohol production compared to the control, although not as significant as Flasks No. 3 and 4.

In summary, the analysis suggests that certain compounds, particularly Fe (CBMBTH)$_2$ Cl$_2$.]Cl.H$_2$O and [Co (HMPBMBTH)$_2$] Cl$_2$. H$_2$O, have notable effects on enhancing both biomass percentage and alcohol production. Iron-containing compounds generally show a stronger influence on biomass conversion, while cobalt-containing compounds tend to favour alcohol production.

Result of this experiments can be represented as follows.



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