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# Literature Study: Complex Compounds Of Zn (II) EDTA, Mn (II) Netilisophyldithiocarbamate, and Lutesium-177(177lu)-Di-N-Butyl Dithiocarbamate In Industry

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**Abstract**

This study is a literature review aimed at analyzing the synthesis, characterization, functions, and potential hazards of three types of complex compounds used in industry, namely Zn(II)-EDTA, Mn(II)-N-ethylisopropyldithiocarbamate, and Lutetium-177(177Lu)-Di-n-butyldithiocarbamate. The research method employed was library research, focusing on reviewing various relevant scientific sources from both national and international journals. The results show that Mn(II)-N-ethylisopropyldithiocarbamate functions as a lubricant additive that enhances viscosity and reduces friction at high temperatures; Zn(II)-EDTA acts as an effective anti-algae agent in industrial cooling water systems due to its strong chelating properties; and 177Lu-Di-n-butyldithiocarbamate serves as a radiotracer in industrial process monitoring owing to its high stability and radiochemical purity. Despite their many advantages, these compounds also pose potential toxic and environmental risks if not properly managed. Therefore, further research is recommended to develop more efficient and environmentally friendly synthesis methods and to ensure their application complies with industrial and radiation safety standards.

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## INTRODUCTION

The study of complex compounds continues to develop along with the increasing use of transition metals in various fields of science and technology. Complex compounds play a crucial role due to their unique coordination properties, which can influence stability, color, catalytic activity, and magnetic properties. The diversity of ligands that can bind to metal ions makes research on the synthesis and characterization of complex compounds increasingly relevant (Huheey & James, 1993; Lawrence, 2010).

This research seeks to contribute to enriching our understanding of the properties of complex compounds, both theoretically and practically. Thus, it is hoped that the results will serve as a reference for the development of coordination chemistry studies and their applications in industry, the environment, and health.

A complex compound is a combination of a central metal ion and one or more ligands that donate their lone pairs of electrons to the central metal ion. This central metal ion is usually a transition element and is capable of accepting lone pairs of electrons from the ligands. The donation of electron pairs by the ligands to the central metal ion produces coordinate covalent bonds, so complex compounds are often also called coordination compounds. The number of coordinate covalent bonds between the central ion and ligands in a complex compound is called the coordination number. Complex compounds have various coordination numbers and structures, ranging from two to twelve, with structures such as linear, tetrahedral, square planar, trigonal bipyrimidal, and octahedral. Typically, complex compounds have a coordination number of six and a general octahedral structure (Huheey, 1993; Lawrence, 2010).

The link between a core ion (metal) that functions as an electron pair acceptor (Lewis acid) and a ligand that functions as an electron pair donor (Lewis base) creates complex compounds.acts as an electron pair acceptor (Lewis acid). The study of complex formation is interesting to study because the complexes formed can provide many benefits, for example as catalysts, drugs and the treatment of heavy metal poisoning. Complex compounds that can be used as catalysts must have stable properties. One of the most stable complex compounds is a complex compound that forms chelates. Nickel complex compounds have been proven to be useful in catalytic processes, namely in Ni(II)-α-diimine used as a catalyst in ethylene polymerization. Polymerization temperature has a significant influence on catalyst activity and the degree of polymer branching. The Ni(II)-α-diimine catalyst produces many branches at high temperatures and at low ethylene pressure, so that the degree of polyethylene branching increases (Chohan et al., 2010; Dindarloo-Inaloo et al., 2020).

Complex compounds play a vital role in human life due to their diverse applications in various fields such as health, pharmaceuticals, industry, and the environment. For example, cobalt complex compounds have been widely used as catalysts, cancer growth inhibitors, and for other purposes (Cotton & Wilkinson, 1989). Complex compounds can be prepared by mixing solutions of metal ions and ligands in a suitable solvent to dissolve both, either with or without heating at a specific temperature (Chohan et al., 2010; Dindarloo-Inaloo et al., 2020).

The complex compounds that exist in the industrial world after we have reviewed from literature and book studies are the complex compounds Zn(II)EDTA, Mn(II)Netilisopropyldithiocarbamate, and Lutesium-177(177Lu)-Di-n-butyl dithiocarbamate. The review from the literature study that has been carried out is about how to synthesize or make each complex compound, the function of each complex compound, the method or process of use, and the advantages and dangers of using complex compounds (Jeremić et al., 2019; Setyawati, 2017).

## METHOD

The research method used in this study is a literature study (library research) that focuses on searching, collecting, and analyzing various scientific sources relevant to the topic of complex compounds. This literature study was chosen because it aligns with the research objectives, namely to gain a deep understanding of the basic concepts, synthesis, characterization, benefits, and potential hazards of complex compounds from both theoretical and applied perspectives (Housecroft & Sharpe, 2018; Lawrence, 2010).

The literature sources used include indexed international and national journals, as well as academically recognized coordination chemistry and inorganic chemistry textbooks. Specifically, this study examines three primary journals as primary sources, selected based on their direct relevance to the research topic and the quality of their publications. In addition, ten additional journals were used as supporting references to enrich the perspective and provide a more comprehensive scientific foundation.

In addition to journals, this study also utilized two primary books as theoretical references, particularly regarding the basic concepts of complex compounds, the principles of coordinate bonding, and their spectroscopic and physical characterization. To complement the analysis, an additional book was used as a secondary reference that provided supporting information and strengthened the theoretical arguments in the discussion (Housecroft & Sharpe, 2018; Lawrence, 2010).

The study process is carried out through several stages, namely: (1) identification and selection of literature according to the relevance of the topic; (2) in-depth reading and recording of important points from each source; (3) critical analysis of the suitability and differences between sources; and (4) preparation of a literature synthesis in the form of a structured scientific paper. With this method, the research is expected to be able to present a complete, systematic, and valid picture of complex compounds and their implications in chemistry and their applications in various fields.

## RESULTS AND DISCUSSION

### Synthesis of Complex Compounds

The synthesis results show that three types of complex compounds, namely Mn(II)-N-ethylisopropyldithiocarbamate, Zn(II)-EDTA, and 177Lu-Di-n-butyldithiocarbamate, can be obtained through a simple coordination reaction method by controlling certain reaction conditions (Setiawan, 2011; Sidik, 1997).

### *Mn(II)-N-Ethylisopropyldithiocarbamate in Lubricants*

In the first study, Mn(II)-N-ethylisopropyldithiocarbamate was synthesized through an in situ method by reacting $MnSO_4 \cdot H_2O$ as a metal ion source with N-ethylisopropyldithiocarbamate ligands that were previously formed from the reaction of N-ethylisopropylamine and carbon disulfide in ethanol solvent. This reaction produced a brown crystalline complex with a yield of 49.59%. According to the characterization data, the Mn(II) ion and the dithiocarbamate ligand have a strong coordination bond, as evidenced by the comparatively high melting point of 399.9 °C. This chemical is non-electrolyte, according to conductivity studies, and the UV-Vis spectra revealed absorption peaks at 230, 250, and 310 nm. This verified that the N–C=S and S–C=S groups, which are characteristics of dithiocarbamate molecules, have $\pi \rightarrow \pi^*$ electronic transitions.

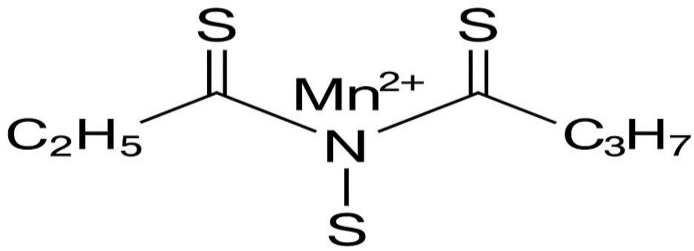


Figure 1. Mn(II)-N-ethylisopropyldithiocarbamate

### *Zn(II)-EDTA*

Meanwhile, Zn(II)-EDTA was successfully synthesized by mixing $ZnCl_2$ and $Na_2EDTA$ solutions in a 1:1 mole ratio. The reaction was carried out in water and methanol solvents by heating at low temperature for one hour until the volume was reduced by one third, then the solution was cooled to obtain crystals. The obtained Zn(II)-EDTA crystals had a cloudy white color. Characterization showed a shift in the maximum wavelength to 752 nm which indicated the formation of new complex bonds. FTIR analysis also confirmed the formation of Zn–O coordination bonds at 478 $cm^{-1}$ and Zn–N at 516 $cm^{-1}$, thus confirming the successful synthesis.

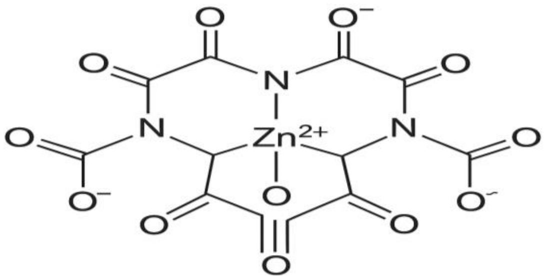


Figure 2. Zn(II)-EDTA (Setiawan, 2011; Sidik, 1997).

***$^{177}$Lu-Di-n-butyldithiocarbamate***

$^{177}$Lu-Di-n-butyldithiocarbamate was synthesized by reacting the radioisotope ^177Lu with the di-n-butyldithiocarbamate ligand obtained from the reaction of di-n-butylamine and carbon disulfide in ammonia medium. The complexation process was carried out at an optimum pH of 5 with a mole ratio of 1:6, producing white crystals with a melting point >350 °C. The UV-Vis spectrum showed a maximum absorption at 244.8 nm, while the FTIR spectrum showed stretching vibrations of the metal–sulfur (Lu–S) bond at 950 $cm^{-1}$. Paper chromatography showed an Rf of 0.87 with a radiochemical purity of 97.10%, indicating that the complex was well formed and stable (Setiawan, 2011; Sidik, 1997).

The DBK (di-n-butyldithiocarbamate) ligand is not commercially available, so for the purposes of this study, ligand synthesis was first carried out. The di-n-butyldithiocarbamate ligand was prepared as the ammonium salt of di-n-butyldithiocarbamate according to the following reaction as presented in figure 3.

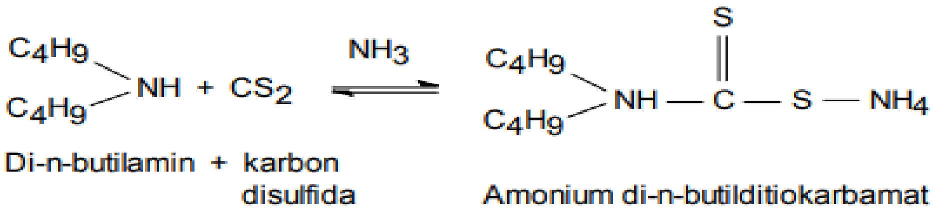


Figure 3. reaction of Ammonium di-n-butyldithiocarbamate formation

Based on the infrared spectrum obtained, it is known that a reaction occurs between lutetium metal and di-nbutyldithiocarbamate ligands, which is characterized by the loss of the C = S group to C – S and the presence of an OH group. The results of the analysis using ultraviolet and infrared spectrometers show that the reaction between lutetium and di-nbutyldithiocarbamate ligands is suspected to have a complex structure as depicted in figure 4.

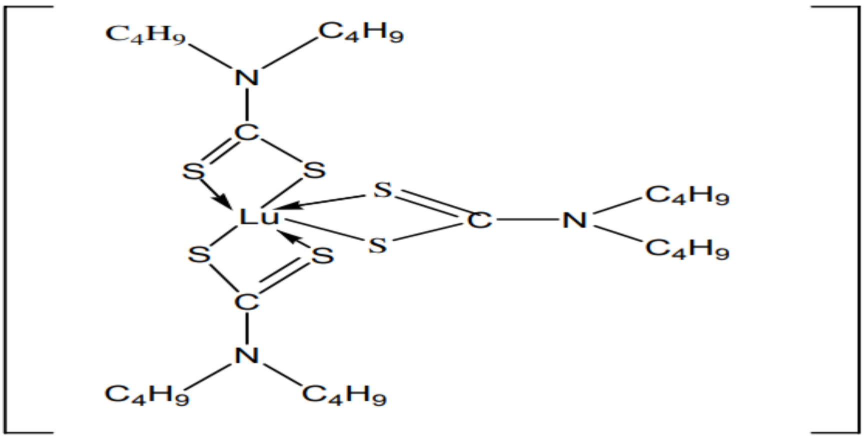


Figure 4. Reaction between lutetium and di-nbutyldithiocarbamate ligands is suspected to have a complex structure

## Function and Working Mechanism

Each complex compound has a specific function that is closely related to its chemical and physical properties.

### *Mn(II)-N-Ethylisopropyldithiocarbamate in Lubricants*

Mn(II)-N-ethylisopropyldithiocarbamate functions as a lubricant additive. This compound improves lubricant performance by forming a thin protective layer on the engine's metal surfaces, thereby reducing friction and minimizing heat. Viscosity test results show that at 40 °C this additive is not very effective, but at 100 °C the viscosity increases significantly. This indicates that at high temperatures the metal-ligand bond is more easily broken, releasing an active protective layer that plays a role in reducing engine wear. Thus, this compound is effective for use in engine conditions operating at high temperatures (Ranggina, 2023).

### *Zn(II)-EDTA in Industrial Cooling Water*

Zn(II)-EDTA acts as an anti-algae agent in industrial cooling water systems. The mechanism involves EDTA's chelating properties, which are able to bind metal ions essential for algae metabolism, thereby inhibiting their growth. Furthermore, the presence of $Zn^{2+}$ enhances the oligodynamic effect, which is the ability to kill microbes at low concentrations. The results showed that Zn(II)-EDTA was able to suppress the growth of green algae by up to 98% and brown algae by up to 87% compared to the positive control using Seyton biocide. This makes Zn(II)-EDTA a more effective and potentially environmentally friendly alternative for controlling biofouling in industry (Nowack, 2002; Setyawati, 2017).

### *$^{177}$Lu -Di-n-Butyldithiocarbamate as a Radiotracer*

$^{177}$Lu-Di-n-butyldithiocarbamate is used as a radiotracer in industrial applications. The radioisotope ^177Lu was chosen because it has a half-life of 6.7 days, sufficient for industrial monitoring activities but not too long, thus reducing environmental impact. This compound releases low-energy gamma radiation that is easily detected by nuclear instruments, thus enabling fluid flow mapping, pipe leak detection, and evaluation of material distribution in industrial processes. Other advantages are its neutral nature and solubility in organic solvents, making it easy to distribute in industrial systems.. (Setiawan, 2011; Sidik, 1997).

## How to Use Complex Compounds

### *Mn(II)-N-Ethylisopropyldithiocarbamate in Lubricants*

The Mn(II)-N-ethylisopropyldithiocarbamate complex compound is used as a lubricant additive. It is used by adding a certain amount of the synthesized complex to the base lubricating oil. In the study, the concentration variations used were 0.05 g, 0.08 g, and 0.1 g of the complex dissolved in 50 mL of acetone before being mixed into the lubricant. The mixture was then tested using a kinematic viscosity bath at 40 °C and 100 °C to determine changes in viscosity. The results showed that this complex compound was more effective in increasing lubricant viscosity at 100 °C than at 40 °C, so its use is recommended for engines operating at high temperatures. (Ranggina, 2023).

### *Zn(II)-EDTA in Industrial Cooling Water*

The use of the Zn(II)-EDTA complex was applied as an anti-algae agent in cooling water systems. The complex compound was dissolved into industrial cooling water samples with varying concentrations of 5 ppm, 10 ppm, 50 ppm, and 100 ppm. The samples were then stored under controlled conditions and shaken for 24 hours to ensure even distribution of the compound. Afterward, algae growth was measured through fluorescent absorbance analysis using a UV-Vis spectrophotometer at wavelengths of 590 nm (green algae) and 550 nm (brown algae). For comparison, samples without treatment (negative control) and samples with 10 ppm

Seyton biocide (positive control) were used. The test results showed that Zn(II)-EDTA was able to significantly suppress algae growth until the 14th day, making its use effective in preventing biofouling in industrial cooling water. (Nowack, 2002; Setyawati, 2017).

### ***$^{177}$Lu -Di-n-Butyldithiocarbamate as a Radiotracer***

The complex compound ^177Lu-Di-n-butyldithiocarbamate is used as a radiotracer in industrial applications, for example for fluid flow tracking, pipeline leak detection, and evaluation of oil or water production systems. Its use begins with the preparation of a complex solution in an organic solvent, which is then injected into the industrial system to be studied. The low-energy gamma radiation emitted by ^177Lu (113 and 208 keV) is detected using nuclear instruments such as dose calibrators, single-channel analyzers, or portable gamma detectors. The movement of the complex compound in the system can be monitored in real time, allowing fluid distribution patterns, leak locations, or production capacity to be determined with high accuracy. Due to its radioactive nature, the use of this compound must comply with radiation safety protocols and international standards regarding worker protection and waste management. (Setiawan, 2011; Sidik, 1997).

### Benefits of Use

The use of these three complex compounds offers several significant advantages.

1. Mn(II)-kompleks able to improve lubricant performance, extend engine life, reduce energy consumption, and support vehicle fuel efficiency.
2. 2. Zn(II)-EDTA is effective in low concentrations, is soluble in water, is more environmentally friendly than other synthetic biocides, and has the potential to reduce maintenance costs for industrial cooling systems. Ethylenediaminetetraacetate (EDTA) has the ability to form stable complexes with certain cations. Ethylenediaminetetraacetate (EDTA) has N and O donor atoms, so it can form chelates, while sulfanilamide has N donor atoms. (Blasco et al., 1996; Camí et al., 2011).
3. 177Lu -complex is very accurate for radiotracer applications, has high sensitivity, suitable half-life, and high radiochemical purity so that it provides precise tracking results..

### Potential Dangers of Use

However, there are also dangerous aspects that need to be considered:: (Zhu et al., 2019).

- Dithiocarbamate compounds such as Mn(II)-N-ethylisopropyldithiocarbamate and 177Lu-Di-n-butyldithiocarbamate are known to cause toxicity to non-target organisms if not managed properly, as they can release toxic reactive sulfur (Setiawan, 2011; Sidik, 1997).
- Zn(II)-EDTA at high doses can cause ecotoxic impacts, such as disrupting the balance of essential metal ions in water and negatively impacting aquatic organisms.
- 177Lu-complex is a radioactive compound, so its use in industry must follow strict procedures regarding radiation protection. Uncontrolled radiation exposure can pose serious health risks to workers and the environment. Therefore, international safety standards and radioactive waste management must be strictly adhered to (Zhu et al., 2019).

## CONCLUSION

Based on the literature review, the three complex compounds—Mn(II)-N-ethylisopropyldithiocarbamate, Zn(II)-EDTA, and Lutetium-177(177Lu)-Di-n-butyldithiocarbamate—demonstrate significant potential in various industrial applications. Mn(II)-N-ethylisopropyldithiocarbamate serves effectively as a lubricant additive that enhances viscosity and reduces friction under high temperatures. Zn(II)-EDTA acts as an efficient anti-algae agent in industrial cooling systems due to its strong chelating ability and relative environmental safety. Meanwhile, 177Lu-Di-n-butyldithiocarbamate functions as a reliable radiotracer in monitoring industrial processes, offering high stability and radiochemical purity.

Despite their advantages, these compounds also pose potential health and environmental risks, particularly due to the toxicity of dithiocarbamate derivatives and the radioactive nature of the lutetium complex. Therefore, strict adherence to safety and waste management regulations is essential. Future research should focus on developing greener synthesis methods, enhancing compound stability, and evaluating their real-world industrial performance under safe and sustainable conditions.

## RECOMMENDATIONS

Based on the results of the literature review, it is recommended that further research focus on experimental testing and quantitative analysis of the stability and effectiveness of each complex compound under real-world industrial conditions. The development of more efficient, environmentally friendly, and low-cost synthesis methods is also a concern, particularly to reduce the potential hazards of dithiocarbamate and radioactive compounds (Zhu et al., 2019).

Furthermore, future research is expected to examine the interaction mechanisms of metal-ligand complexes using advanced spectroscopic approaches (such as XRD, NMR, or EPR) to gain a deeper understanding of their structure and electronic properties. In the context of chemistry education, the study of these complex compounds is also recommended as contextual learning materials, so students can understand the application of coordination chemistry concepts in industry, the environment, and health (Housecroft & Sharpe, 2018; Lawrence, 2010).

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