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Synthesis and antimicrobial action of Ag-Zeolite A

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***Abstract*— The present work involves the synthesis, characterization, and antimicrobial activity of silver-ion-exchanged zeolite A (Ag-zeolite A). The synthesized material properties were studied using SEM and EDX. The particle size distribution was also analyzed. The antimicrobial activity was examined against the Gram-negative Escherichia coli. The antimicrobial tests showed that the pure zeolite A has no inhibitory effect. However, silver loaded zeolite A had excellent antimicrobial properties. The results also indicated that the higher silver concentration, the more antimicrobial efficacy was achieved. The detected antimicrobial properties were generated by the silver present in the zeolite structure, while the zeolite framework was only responsible for the sustained release of the silver ions. Consequently, this material would impede microbial growth on surfaces and hence reduce infection risk. This makes Ag-zeolite A a good choice for combination with various materials in order to manufacture medical devices, surfaces, textiles, or household items where antimicrobial properties are beneficial and necessary.**

I. INTRODUCTION

The word antimicrobial has a Greek origin and it consists of the words anti (against), mikros (little) and bios (life) and refers to all agents that act against microbial organisms. There are other terms like antibacterial and antiviral indicating the special type of organism affected. For instance, antimicrobial agent affects yeasts, fungi, viruses and bacteria whereas antibacterial agents specifically affect bacteria.

The mechanism of how antimicrobial agents work is quite simple: they penetrate the cell wall of the microbe and disrupt key cell functions so the microbe cannot grow or reproduce. Moreover, when treated with cells, silver ion damages the cell wall and leads to leakage of cytoplasm so that the cell is dehydrated, shrunken and becomes less microbial. Due to this reason, in order an antimicrobial agent to be effective, it should kill almost 100% of all viable microbes. The efficacy of an antimicrobial agent is determined by looking at the killing percent of the viable microbes (i.e. 99% killing of E.coli bacteria).

There are some metals which are used as antimicrobial agents such as zinc, copper, silver, nickel, etc. Among all the metals with antimicrobial feature, it is found out that Silver has the highest efficacy against microbes. Silver ions are very attractive because of their strong activity and wide spectrum. By wide spectrum, the range of microbes that Silver affect should be understood. The antimicrobial action of silver is proportional to the silver ion (Ag+) released and its availability to interact with bacterial or fungal cell membranes. Silver is inert when it is in molecular form; however, when it is dissolved in water or an aqueous solution, it gains a positive charge which turns Silver into an effective antimicrobial agent. Zeolites are microporous aluminosilicates that are most commonly used as adsorbents or catalysts. They have a porous structure that can accommodate a wide variety of cations, such as Na^+, K^+, Ca^{2+}, Mg^{2+} and others. These positive ions are rather loosely held and can readily be exchanged for others in a contact solution

Generally, zeolites have a general formula $[(SiO_2)(AlO_2)x]M_{x/n}^{n+} \cdot w\ H_2O$ where M is a cation with positive charge equal to n. It is usually a group I or II metal ion. The silicon and aluminum oxide part of the substance provide the framework of interconnected tetrahedral structures [1].

Zeolites can be used as effective antimicrobial agents because the native cations in the zeolite structure can be exchanged with heavy metal ions that have antimicrobial activity [2-4]. Among them, silver ions are the most attractive because of their strong activity and wide spectrum [5]. Zeolites can bind a large amount of silver ions in its micropores. Silver ions are released from the zeolite matrix by exchange with other cations in solution.