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Proceeding Paper

Antimicrobial Activity of Ba-MOF †

Mina Aghaee [1], Mahnaz Abbaszadeh Alishahi [1] and Faranak Manteghi [1,*]

[1] Department of Chemistry, Iran University of Science and Technology, Tehran, Iran
* Correspondence: f_manteghi@iust.ac.ir
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Abstract: Increasing the tolerance and resistance of pathogens to conventional antibiotics is a global health issue and there is a need to use effective and new substances. MOFs are highly functional materials with antimicrobial properties come from their composition, structure, and high internal volume, which could be a source for antimicrobial guest molecules integrated in the pore. In addition, MOF can contain more than one type of metal ion in the same structure. In this work, a metal-organic framework, $[Ba(H_2btec)\cdot H_2O]_n$ was synthesized by the deposition method using benzene-1,2,4,5-tetracarboxylic acid (H4btec) and $Ba(NO_3)_2$. Characterization of MOF was performed using XRD, XRF, FTIR, SEM analyses. The metal-organic framework used against gram-positive and gram-negative bacteria including Keleb peneumonia, Staph coccus aureus, Staph sapropphyticus, Esherichia coli.

Keywords: MOF; antibacterial; barium

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1. Introduction

Metal-organic frameworks (MOFs) are a class of porous hybrid materials constructed from metal ions and organic ligands, linked through coordination bonds. On the other hand, MOFs have been in focus of consideration due to their unique porous structure with significant characteristics like high surface area, tunable chemical composition as well as various pore size distribution. One of their important properties is antibacterial activity that can be increased by choosing metal ions and/or linkers with antibacterial properties [1,2]. MOFs can contain more than one type of metal ion in the same structure and the use of several metals with antibacterial properties intensifies this feature. Also, the ligand used to prepare the framework can have antibacterial properties and the accumulation of the MOFs can cause the destruction of the bacteria wall and destroy the bacteria [1]. The important point in the synthesis of MOFs that show antibacterial properties is to pay attention to pearson's hard and soft acid and base theory. In order to have MOFs with antibacterial properties, metal ions must be able to separate easily, if the acid and base are both hard types or both soft types, the bond between them will be very strong and metal ions cannot be released and show antibacterial properties. In the synthesized MOF ($[Ba(H_2btec).H_2O]_n$), the linker used (benzene-1,2,4,5-tetrakis carboxylic acid) is hard but barium metal is not considered as a hard acid and can show antibacterial properties.[3]

2. Experimental

2.1. Preparation of $[Ba(H_2btec)\cdot H_2O]_n$

The amount of 1 mol benzene-1,2,4,5-tetracarboxylic acid (H_4btec) was dissolved in 20 cc water and 10 cc ethanol then stirred in room temperature until dissolved completely. Afterwards, 2 mol $Ba(NO_3)_2$ was dissolved in 10 cc water. Then the two solutions were mixed on stirring at 100 °C and 700 rpm for 2h, then cooled in room temperature. The white powder was dried in room temperature for 1 day [4].

2.2. Characterization

The obtained powder, $[Ba(H_2btec)\cdot H_2O]_n$ was characterized by XRD, XRF, FTIR and SEM methods.

The XRD pattern of $[Ba(H_2btec)\cdot H_2O]_n$ is compared with the simulated pattern in Figure 1. It shows that it is correctly synthesized.

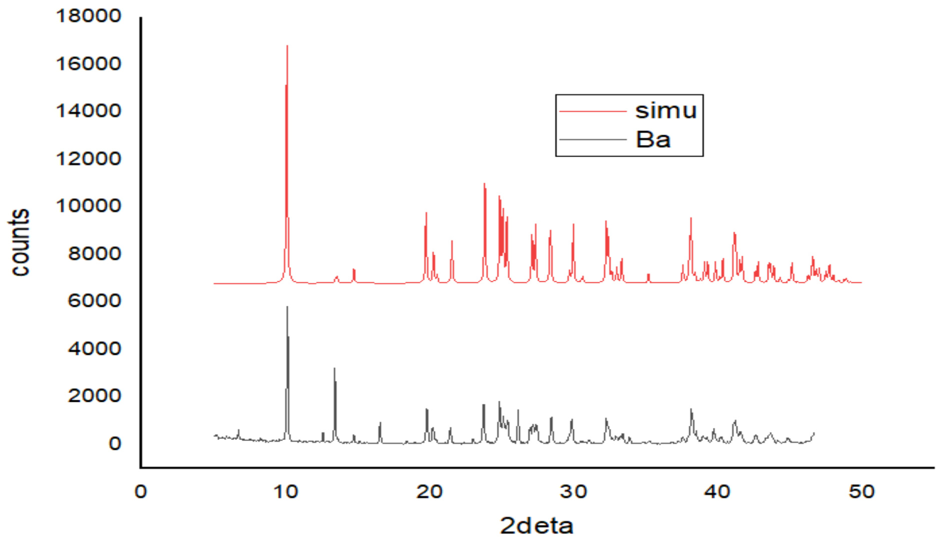

Figure 1. XRD Pattern of $[Ba(H_2btec)\cdot H_2O]_n$.

In XRF analysis of $[Ba(H_2btec)\cdot H_2O]_n$ shown in Table 1, can be seen the percentage of BaO equal to 100% which confirms the presence of only Barium in the MOF.

Table 1. The XRF result of $[Ba(H_2btec)\cdot H_2O]_n$.

Elements	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2
wt %	-	-	-	-	-	-	-	-	-
Elements	Fe_2O_3	V_2O_5	MnO	Cr_2O_3	La	Sr	Zn	BaO	Pb
wt %	-	-	-	-	-	-	-	100.000	-
Elements	F	Zr	Cl	Ce	Co	Mo	Ca	Cu	Ho
wt %	-		-	-	-	-	-	-	-

The FTIR spectrum of $[Ba(H_2btec)\cdot H_2O]_n$ is shown in Fig 2. The spectrum shows a sharp peak at 1500 cm^{-1} which is related to the carbon-carbon double bond in the aromatic ring, the peak in 1700 cm^{-1} is related to the symmetric stretching bond of carboxylic groups, and the short and broad peak at 3000 cm^{-1} is related to the C–H bond of the aromatic ring.

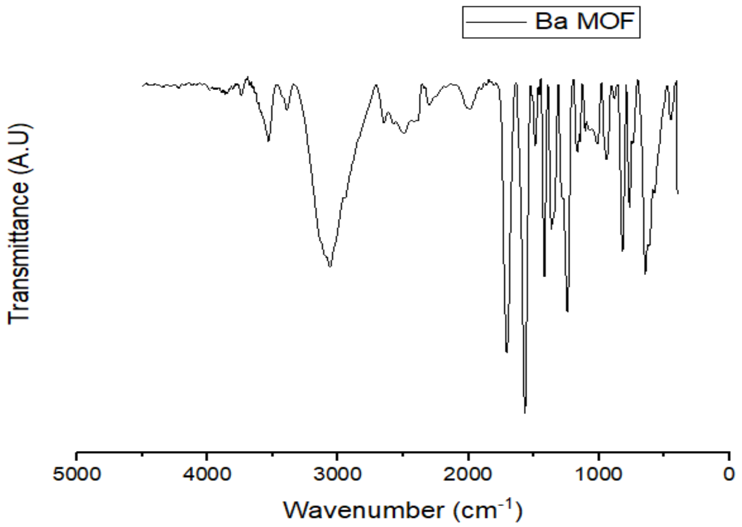

Figure 2. FTIR spectrum of $[Ba(H_2btec)\cdot H_2O]_n$.

The SEM micrographs of $[Ba(H_2btec)\cdot H_2O]_n$ were shown in Figure 3, in which the rod shape with average particles of MOF has the size of 1 μm to 3 μm.

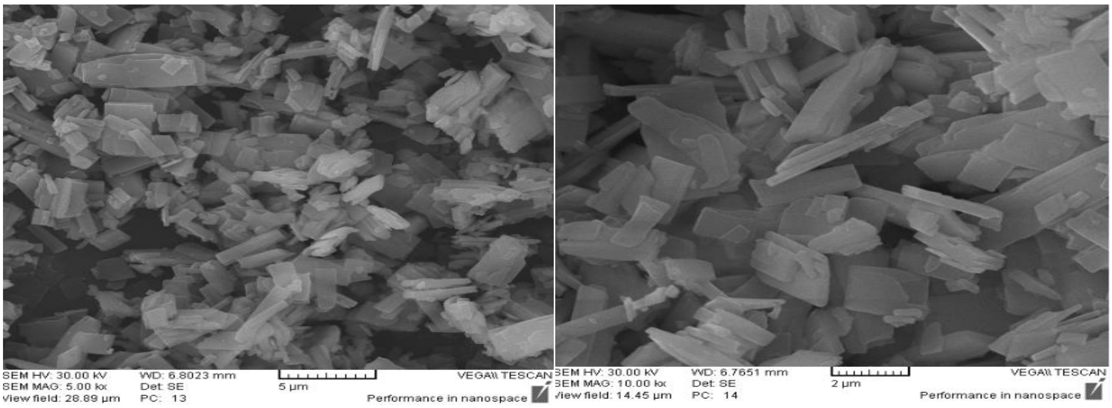

Figure 3. SEM of $[Ba(H_2btec)\cdot H_2O]_n$.

2.3. Antibacterial Activity

Antibacterial Activity of $[Ba(H_2btec)\cdot H_2O]_n$ against gram positive and gram negative bacteria were tested. The bacteria including Keleb peneumonia, Staph coccus aureus, Staph sapropphyticus, Esherichia coli. The results are shown in Figure 4a-e and summarized in Table 2. In all cases was defined the inhibition zone diameter from $[Ba(H_2btec)\cdot H_2O]_n$.

Table 2. The behavior of $[Ba(H_2btec)\cdot H_2O]_n$.

Test bacteria with $[Ba(H_2btec)\cdot H_2O]_n$	**Inhibition Zone diameter (mm)**
Ps. Aeruginosa	10.725
Keleb Peneumonia	11.31
Staph Coccus aureus	13.527
Staph Sapropphyticus	12.712
Ecoli	14.360

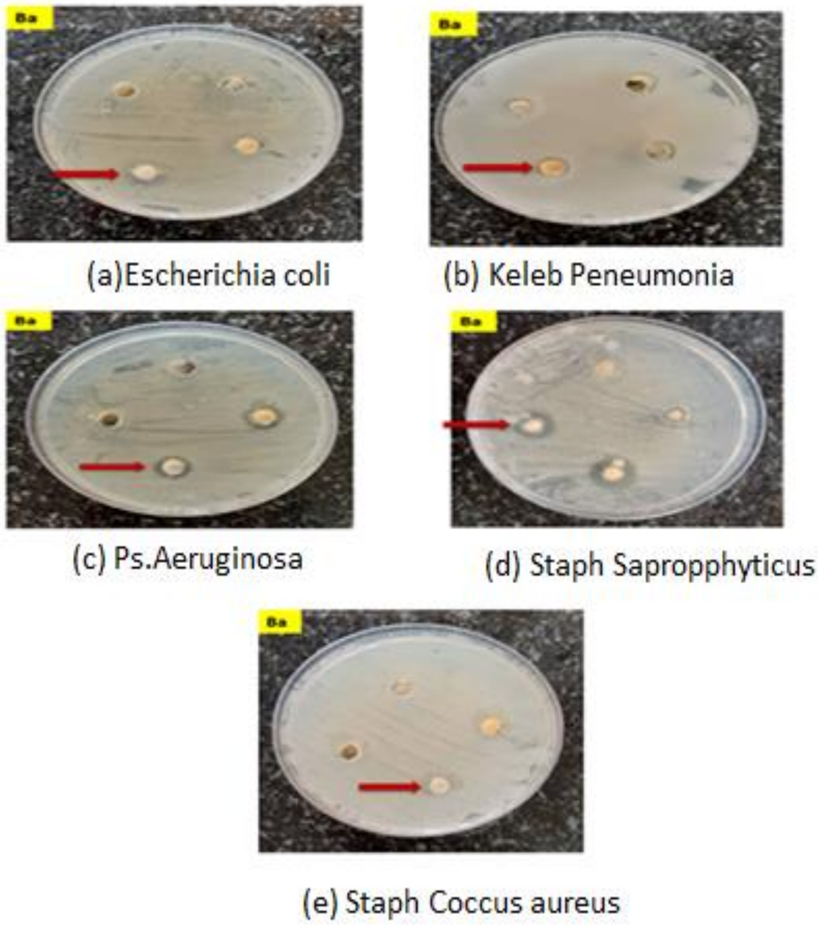

Figure 4. Images of antibacterial test results for gram-negative (a-c) and gram-positive (d,e) bacteria on $[Ba(H_2btec)\cdot H_2O]_n$.

3. Conclusions

In this research, $[Ba(H_2btec)\cdot H_2O]_n$ was synthesized using benzene-1,2,4,5-tetracarboxylic acid as linker and $Ba(NO_3)_2$ as metal source, and they were applied against gram positive and gram negative bacteria and it has shown relatively good performance against both groups. To the best of our knowledge, the title MOF is applied against bacteria for the first time, it is also synthesized by green chemistry and environmentally friendly solvents.

Institutional Review Board Statement:

Informed Consent Statement:

Data Availability Statement:

Conflicts of Interest:

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