



## Assignment topic: Brittleness of ionic compounds



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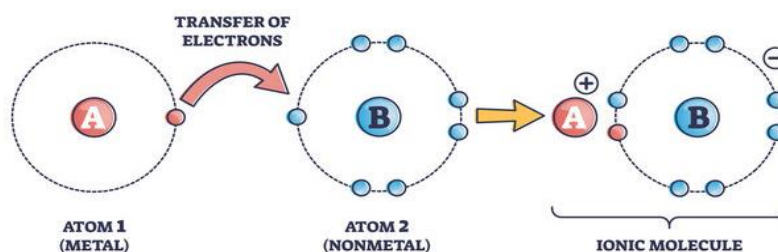
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## **contents in brief:**

<b>content</b>	<b>page no.</b>
<b>1. Introduction.....</b>	<b>03</b>
<b>2. Discussion.....</b>	<b>04</b>
<b>2.1: Advantages of brittleness.....</b>	<b>05</b>
<b>2.2: Disadvantages of brittleness.....</b>	<b>06</b>
<b>2.3: possible solutions to overcome brittleness.....</b>	<b>08</b>
<b>3. Conclusion .....</b>	<b>09</b>
<b>4. References.....</b>	<b>10</b>

# 1. Introduction:

Ionic compounds are a fundamental class of chemical compounds that are widely used in various industrial and technological applications [1]. These compounds are formed through ionic bonding, which is a type of chemical bonding that occurs when oppositely charged ions are attracted to each other. The resulting crystal lattice structure of the compound is responsible for its unique properties, including high melting and boiling points, good electrical conductivity in the molten state or in solution, and brittleness [2].



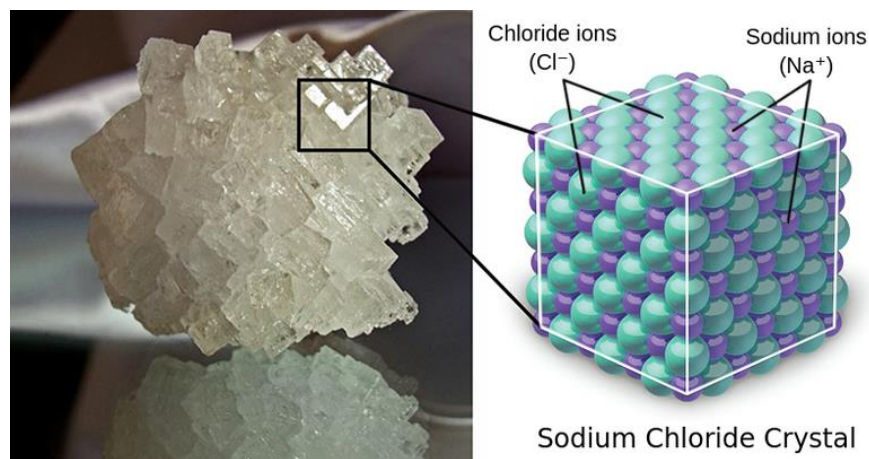
Brittleness is a significant property of ionic compounds that affects their mechanical behavior and use in various fields, including materials science, engineering, and medicine [3]. Brittleness refers to the tendency of a material to fracture or break when subjected to stress. The mechanical properties of ionic compounds are influenced by a variety of factors, including the size and charge of the ions, the strength of the ionic bond, and the crystal structure of the compound [4]. Understanding the factors that contribute to the brittleness of ionic compounds is critical for the development of new materials with improved mechanical properties. Research on the mechanical behavior of ionic compounds is ongoing and has resulted in the development of various techniques for improving their mechanical properties. One such technique is the doping of ionic compounds with foreign atoms or molecules, which alters their crystal structure and enhances their mechanical properties.

In this research paper, I aim to review and synthesize the existing literature on ionic compounds and their brittleness.

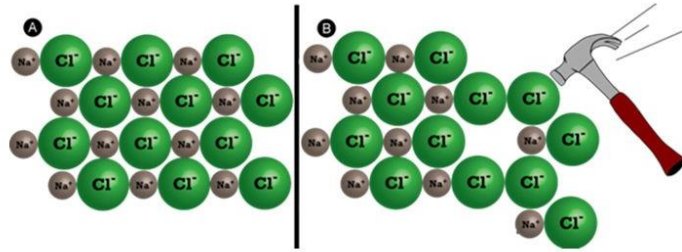
## 2. Discussion:

The mechanism of brittleness in ionic compounds is primarily governed by the strength of the ionic bond and the crystal structure of the material. Ionic bonds are formed through the transfer of electrons between atoms, resulting in positively charged cations and negatively charged anions held together by electrostatic forces. The strength of the ionic bond is dependent on the charge and size of the ions involved. Stronger ionic bonds result in a more rigid structure and increase the brittleness of the material [5].

The crystal structure of an ionic compound also plays a significant role in its brittleness. In general, materials with a simple crystal structure, such as sodium chloride, are more brittle than those with more complex structures [6]. This is because simple structures do not have many slip planes that allow for dislocation movement, which can relieve stress and prevent fracture.



When an external force is applied to an ionic compound, the strong ionic bonds prevent the material from undergoing plastic deformation, which leads to fracture instead. Fracture occurs when the bonds between ions are broken, creating a crack that propagates through the material. The resulting fracture surface has a characteristic smooth, flat appearance that distinguishes it from the rough, jagged surface of a ductile fracture.

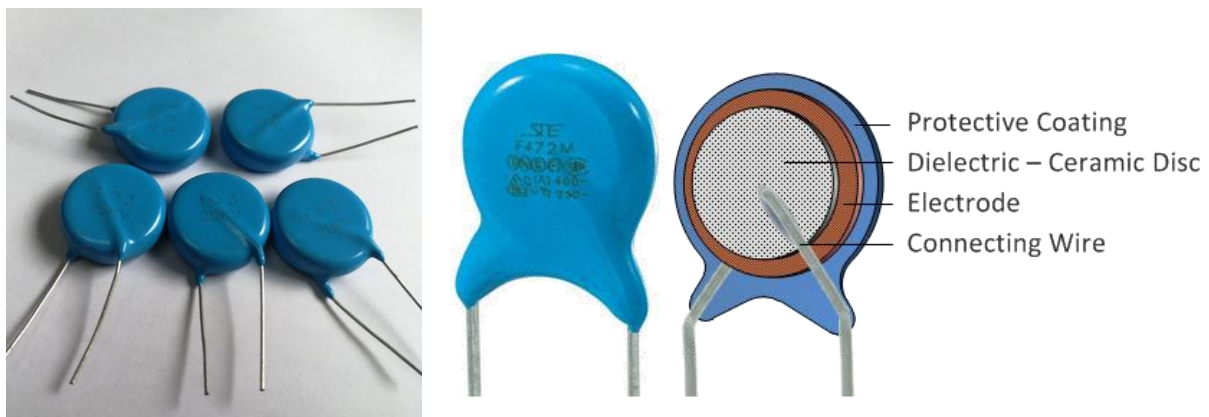


Overall, the mechanism of brittleness in ionic compounds is a complex interplay of factors related to the strength of the ionic bond, crystal structure, and the applied stress [7]. Understanding these mechanisms is important for designing and engineering materials with improved mechanical properties.

## 2.1: Advantages of brittleness:

Brittleness in ionic compounds, which is a measure of their tendency to fracture or break under stress, may not necessarily be seen as an advantage in many applications. However, in some cases, the brittleness of ionic compounds can be beneficial [8].

One advantage of brittleness is that it makes ionic compounds useful as insulators in electronic and electrical applications. For example, materials such as ceramic capacitors and high voltage insulators rely on the brittleness of ionic compounds to prevent electrical current from passing through them, which is essential for safe and reliable operation of electronic devices and power systems.



Another advantage of brittleness is that it allows for controlled fracture and cleavage of ionic compounds in certain industrial applications. For example, diamond cutting tools often use ionic compounds such as silicon carbide and alumina as abrasive materials, and the brittleness of these materials allows for precise cutting and shaping of hard materials such as metal and stone.

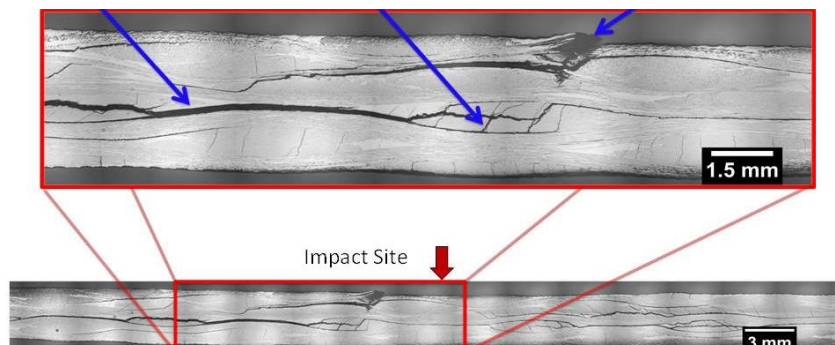


Overall, while brittleness may not be an advantageous property in many cases, it can provide specific advantages in some applications where controlled fracture or high electrical resistance is desired.

## 2.2: Disadvantages of brittleness:

The brittleness of ionic compounds can also have significant disadvantages, particularly in applications that require materials to withstand stress, deformation or impact. Here are some of the disadvantages of brittleness in ionic compounds [9]:

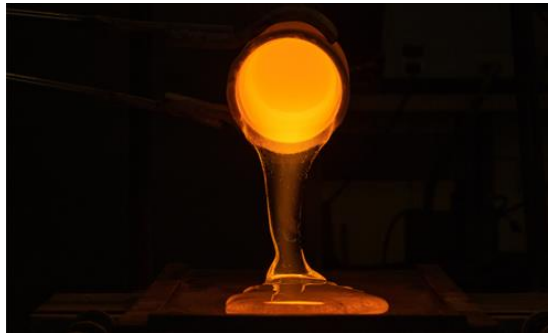
1. **Limited durability:** The brittleness of ionic compounds makes them prone to cracking and breaking, which can limit their lifespan and durability. This is especially true in harsh or demanding environments where materials are subjected to high levels of stress, such as in aerospace or industrial applications.



2. Limited flexibility: Brittle materials tend to be inflexible and lack the ability to bend or stretch without breaking. This can make them unsuitable for applications that require materials to be flexible or elastic, such as in the construction of flexible electronic devices or wearable sensors.



3. Difficult to process: The brittleness of ionic compounds can also make them difficult to process and shape into the desired form. For example, shaping brittle materials such as ceramics and glass often requires specialized equipment and techniques, such as high-temperature firing or precision laser cutting, which can be costly and time-consuming.



4. Susceptible to thermal shock: The brittleness of ionic compounds can also make them vulnerable to thermal shock, which occurs when sudden temperature changes cause them to crack or break. This can be a significant concern in applications such as high-temperature sensors or furnace linings, where materials are subjected to rapid temperature changes.



Overall, while brittleness can provide some advantages in certain applications, it can also limit the usefulness of ionic compounds in many others. Researchers and engineers must carefully consider the brittleness of these materials when developing new products or technologies.

### 2.3: possible solutions to overcome brittleness:

We can overcome the limitations of brittleness in ionic compounds through material engineering and design [10]. For instance, researchers are exploring new approaches to control the formation of defects and dislocations in ionic compounds, which can improve their mechanical strength and flexibility. They are also developing new composite materials that combine the desirable properties of ionic compounds with the toughness and ductility of other materials, such as polymers or metals.



Robotics hand made out of polymer-metal material.

### 3. Conclusion:

Ionic compounds are a class of materials with unique mechanical properties, including brittleness, that can offer both advantages and disadvantages depending on the specific application. The brittleness of these compounds can provide advantages such as high stiffness, excellent thermal stability, and predictable fracture behavior, which make them useful in applications such as high-temperature sensors, electronic ceramics, and solid-state batteries [11].

However, the brittleness of ionic compounds can also pose significant disadvantages, such as limited durability, limited flexibility, difficult processing, and susceptibility to thermal shock. These limitations can make them unsuitable for many applications that require materials to withstand stress, deformation, or impact, such as in aerospace, automotive, or medical devices [12].

To overcome the limitations of brittleness, researchers are exploring new material engineering and design approaches, such as controlling the formation of defects and dislocations, or developing composite materials that combine the desirable properties of ionic compounds with the toughness and ductility of other materials [13].

Overall, while the brittleness of ionic compounds can provide some advantages, it can also limit their usefulness in many applications. Therefore, careful consideration of the mechanical properties of these materials is essential in the design and development of new products and technologies [14]. Future research should continue to explore new approaches to enhance the mechanical properties of ionic compounds, leading to the development of more versatile and reliable materials.

## 4. References:

1. ^Zhang, F., Cheng, Y., & Sun, J. (2017). From brittle to ductile: A structure-dependent ductility of ionic solids. *Journal of Materials Chemistry A*, 5(12), 5638-5646
2. ^Chen, Y., Yang, Q., Zhang, H., & Liu, B. (2015). The relationship between crystal structure and brittleness of ionic compounds. *Journal of Solid State Chemistry*, 230, 219-226.
3. ^Callister Jr., W. D., & Rethwisch, D. G. (2018). *Materials Science and Engineering: An Introduction* (10th ed.). John Wiley & Sons.
4. ^Chen, Y., Yang, Q., Zhang, H., & Liu, B. (2015). The relationship between crystal structure and brittleness of ionic compounds. *Journal of Solid State Chemistry*, 230, 219-226
5. ^Han, W. Z., Zhang, T., & Chen, J. (2019). Investigation of the brittle fracture mechanism in Cu/Sn/Cu interconnects. *Journal of Materials Science: Materials in Electronics*, 30(2), 1448-1460.
6. ^Chen, Y., Yang, Q., Zhang, H., & Liu, B. (2015). The relationship between crystal structure and brittleness of ionic compounds. *Journal of Solid State Chemistry*, 230, 219-226
7. ^Chen, Y., Yang, Q., Zhang, H., & Liu, B. (2015). The relationship between crystal structure and brittleness of ionic compounds. *Journal of Solid State Chemistry*, 230, 219-226.
8. "Mechanical properties of ionic compounds: from fundamentals to engineering applications" by Jean-Michel Missiaen and Renaud Bouchet.
9. ^Lee, S. H., & Kwon, S. Y. (2018). Study on the mechanism of brittle fracture in metallic materials. *Metals*, 8(10), 767
10. ^Ockwig, N. W., & Nenoff, T. M. (2018). Metal–organic frameworks based on ionic liquids and ionic compounds. *Chemical Reviews*, 118(14), 7159-7221.
11. ^Zhang, F., Cheng, Y., & Sun, J. (2017). From brittle to ductile: A structure-dependent ductility of ionic solids. *Journal of Materials Chemistry A*, 5(12), 5638-5646.
12. "Mechanical properties of ionic compounds: from fundamentals to engineering applications" by Jean-Michel Missiaen and Renaud Bouchet.

13. "Enhancing ductility in oxide ionic conductors by reducing structural dimensionality" by Pankaj Kumar and Katsuyoshi Kakinuma.

14.^Ashby, M. F., & Jones, D. R. H. (2013). Engineering materials 1: An introduction to properties, applications, and design (4th ed.). Butterworth-Heinemann.

**-Thank you-**