

# HMO-Glasses with Sb<sub>2</sub>O<sub>3</sub> and TeO<sub>2</sub>

Subjects: Materials Science, Composites

Contributor: Hesham Zakaly

Among the different types of glasses, heavy metal oxide glasses (HMO) have received a lot of interest lately because of their low phonon characteristics. Glasses with more than 50% mol percent of a heavy metal cation are heavy metal oxide glasses. The glasses TeO<sub>2</sub>, Sb<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, and PbO are repetitive members of the HMO glass family. These glasses are excellent photonic matrices, due to their larger transparency interval that covers the visible to mid-infrared range, better non-linear optical characteristics, greater solubility of rare-earth ions, and lower phonon energies than conventional silicate, borate, and phosphate glasses. Apart from their excellent thermal, mechanical, and chemical durability, heavy metal oxide glasses have outstanding optical and electrical characteristics, including a high refractive index and dielectric constant.

Keywords: HMO glasses ; radiation shielding ; TeO<sub>2</sub> ; Sb<sub>2</sub>O<sub>3</sub>

---

## 1. Overview

The radiation shielding characteristics of samples from two TeO<sub>2</sub> and Sb<sub>2</sub>O<sub>3</sub>-based basic glass groups were investigated in this research. TeO<sub>2</sub> and Sb<sub>2</sub>O<sub>3</sub>-based glasses were determined in the research as six samples with a composition of 10WO<sub>3</sub>-(x)MoO<sub>3</sub>-(90 - x)(TeO<sub>2</sub>/Sb<sub>2</sub>O<sub>3</sub>) (x = 10, 20, 30). A general purpose MCNPX Monte Carlo code and Phy-X/PSD platform were used to estimate the radiation shielding characteristics. Accordingly, the linear and mass attenuation coefficients, half value layer, mean free path, variation of the effective atomic number with photon energy, exposure and built-up energy factors, and effective removal cross-section values were determined. It was determined that the results that were produced using the two different techniques were consistent. Based on the collected data, the most remarkable findings were found to be associated with the sample classified as T80 (10WO<sub>3</sub> + 10MoO<sub>3</sub> + 80TeO<sub>2</sub>). The current study showed that material density was as equally important as composition in modifying radiation shielding characteristics. With the T80 sample with the greatest density (5.61 g/cm<sup>3</sup>) achieving the best results. Additionally, the acquired findings were compared to the radiation shielding characteristics of various glass and concrete materials. Increasing the quantity of MoO<sub>3</sub> additive, a known heavy metal oxide, in these TeO<sub>2</sub> and Sb<sub>2</sub>O<sub>3</sub>-based glasses may have a detrimental impact on the change in radiation shielding characteristics.

## 2. Glass-Based Materials

Current findings have conclusively demonstrated that glass-based materials have a wide range of applications in various technology and industry sectors. In addition to this, working with glasses is quite flexible, both in terms of development and structural flexibility. This enables researchers to identify the most appropriate structure for their intended function by altering a range of different glass designs, which they can then test. However, each glass manufacturing process necessitates developing a unique set of characterization methods, based on experimental and modeling approaches, to ensure that the results are understandable and acceptable for the purposes for which they are designed. Among the different types of glasses, heavy metal oxide glasses (HMO) have received a lot of interest lately because of their low phonon characteristics <sup>[1][2]</sup>. Glasses with more than 50% mol percent of a heavy metal cation are heavy metal oxide glasses. The glasses TeO<sub>2</sub>, Sb<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, and PbO are repetitive members of the HMO glass family. These glasses are excellent photonic matrices, due to their larger transparency interval that covers the visible to mid-infrared range, better non-linear optical characteristics, greater solubility of rare-earth ions, and lower phonon energies than conventional silicate, borate, and phosphate glasses. Apart from their excellent thermal, mechanical, and chemical durability, heavy metal oxide glasses have outstanding optical and electrical characteristics, including a high refractive index and dielectric constant. Due to their outstanding properties, heavy metal oxide glasses are excellent candidates for many optoelectronic applications, including fiber optics, lasers, and sensors. However, material density (g/cm<sup>3</sup>) is a significant feature of candidate materials for gamma radiation shielding applications. The literature reviewed showed that HMO glasses had been evaluated in terms of their gamma-ray attenuation properties, thanks to their high material density. In this regard, Celikbilek Ersundu et al. have performed different types of studies on different types of fabricated HMO glasses with

nominal compositions of  $K_2O-WO_3-TeO_2$  and  $ZnO-MoO_3-TeO_2$  [3][4]. According to their findings, K30W60T10 and Z10M10T80 glasses were reported as the most effective shielding glasses, owing to their higher performance against an ionizing gamma-ray. Our review showed that the similarity between these two glass samples is that they have the maximum  $TeO_2$  ratio in their structure. Additionally, a study of the literature revealed that many studies examined HMO reinforced glasses. For instance, Al-Hadeethi and Sayyed have analysed some HMO doped borosilicate glasses by using Geant4 simulation code [5]. Their findings showed that the inclusion of the three dopants, such as  $Bi_2O_3$ ,  $BaO$ , and  $TiO_2$  resulted in a drop in the HVL (the thickness of the material at which the intensity of radiation entering it is reduced by one half), which resulted in an improvement in the attenuation performance of the studied HMO glasses. In another study, D'Souza et al. investigated the effect of  $Bi_2O_3$  on the structural, optical, mechanical, radiation shielding, and luminescence characteristics of borosilicate glasses containing HMO [6]. Their results indicated that with repeated additions of  $Bi_2O_3$ , the gamma-ray shielding capacity rose, but the neutron attenuation capacity dropped. The results of our earlier investigations have prompted us to do further research on HMO glasses that incorporate more comprehensive ideas. Following a successful search of the literature, six different HMO glasses with various substitutions were identified and successfully tested, to better understand the potential effects of substituted heavy metal oxides, such as  $TeO_2$  and  $Sb_2O_3$  [7]. The current investigation aims to evaluate the direct contributions of  $TeO_2$  and  $Sb_2O_3$  on HMO glasses, in terms of gamma-ray attenuation properties. In addition to nuclear radiation (gamma and neutron) shielding characteristics, the synergistic effects of the substitutions on nuclear radiation shielding behaviors will be discussed. Additionally, the data will be compared to certain existing shielding materials and shielding glasses to determine whether the investigated glasses are potentially superior to traditional and disadvantageous shields.

### 3. Conclusions

One of the best examples that can be cited in the field of material science and its applications is the use of high quality and hardened glass materials as a shielding material in medical, industrial, and radiation research fields. According to the purpose and type of radiation field used, it is necessary to characterize each glass material in detail and determine its properties before use. Heavy metal oxide (HMO) glasses have always been an interesting glass group, in terms of its density and optical properties. This study aimed to provide important results on some novel HMO glasses containing heavy metal cations with a high ratio that are preferred in optoelectronics, due to their high transmittances in the visible and mid-IR region. These findings indicated that these new glasses had properties comparable to those of traditional materials. Additionally, it was found that the T80 ( $10WO_3 + 10MoO_3 + 80TeO_2$ ) sample's gamma shielding capabilities, which were the greatest among the manufactured HMO glasses, were effective at greater levels than other materials, such as some glass shields and different types of concrete. However, it can be concluded that certain kinds of radiation, such as alpha, proton, and neutron, are worth further investigation. Furthermore, mechanical and thermal properties and elastic moduli are also worth further investigation, since durability and thermal conductivity are other important properties for any shielding material.

### References

1. Ramesh, P.; Gangareddy, J.; Sathish, K.N.; Pramod, A.G.; Hegde, V.; Pasha, U.M.; Khan, S.; Annapurna, K.; Sayyed, M.I.; Abdullah, A.M.S.; et al. Effect of heavy metal oxides on photoluminescence and spectroscopic attributes of  $Eu^{3+}$  activated borate glasses. *Opt. Mater.* 2021, 114, 110933.
2. Alharbi, T.; Mohamed, H.F.M.; Saddeek, Y.B.; El-Haseib, A.Y.; Shaaban, K.S. Study of the  $TiO_2$  effect on the heavy metal oxides borosilicate glasses structure using gamma-ray spectroscopy and positron annihilation technique. *Radiat. Phys. Chem.* 2019, 164, 108345.
3. Ersundu, M.Ç.; Ersundu, A.E.; Sayyed, M.I.; Lakshminarayana, G.; Aydin, S. Evaluation of physical, structural properties and shielding parameters for  $K_2O-WO_3-TeO_2$  glasses for gamma ray shielding applications. *J. Alloys Compd.* 2017, 714, 278–286.
4. Ersundu, M.Ç.; Ersundu, A.E.; Gedikoğlu, N.; Şakar, E.; Büyükyıldız, M.; Kurudirek, M. Physical, mechanical and gamma-ray shielding properties of highly transparent  $ZnO-MoO_3-TeO_2$  glasses. *J. Non-Cryst. Solids* 2019, 524, 119648.
5. Al-Hadeethi, Y.; Sayyed, M.I. Analysis of borosilicate glasses doped with heavy metal oxides for gamma radiation shielding application using Geant4 simulation code. *Ceram. Int.* 2019, 45, 24858–24864.
6. D'Souza, A.N.; Prabhu, N.S.; Sharmila, K.; Sayyed, M.I.; Somshekarappa, H.M.; Lakshminarayana, G.; Mandal, S.; Kath, S.D. Role of  $Bi_2O_3$  in altering the structural, optical, mechanical, radiation shielding and thermoluminescence properties of heavy metal oxide borosilicate glasses. *J. Non-Cryst. Solids* 2020, 542, 120136.

7. Ersundu, A.E.; Ersundu, M.Ç.; Gedikoğlu, N. A comparative study on WO<sub>3</sub> + MoO<sub>3</sub> containing TeO<sub>2</sub> and Sb<sub>2</sub>O<sub>3</sub>-based heavy metal oxide glasses. *J. Non-Cryst. Solids* 2020, 541, 120093.
- 

Retrieved from <https://encyclopedia.pub/entry/history/show/30201>