NEODYMIUM-DOPED TELLURITE GLASSES FOR LASER APPLICATIONS: A BIBLIOMETRIC REVIEW

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ABSTRACT

Research on properties of zinc-tellurite glasses for laser devises application has increased rapidly in recent years, so efforts are needed to understand the status of trends and their development to support these trends. The specific objectives of this review are to analyze document type, source document, top affiliation, top source title, subject area, top 5 cited publications. The database used is the Scite.ai database. The results show that the development of this research has increased exponentially over the last five years. The most common types of documents are articles, journal document sources, the most sponsored funding is the National Natural Science Foundation of China (5). In the top source title, "Rsc Advances" is the main source of the research publications (206). The top authors affiliation on the research of properties of zinc-tellurite glasses is the French National Centre for Scientific Research. For the top-cited author, Anthony et al., (2016) is recognized as the most citated author (56). The author with the highest number of publications is Adam Gali (18). The implication of this research is to find some examples of novelty in zinc-tellurite glasses for laser devises research so that this review can be used as a reference for future research. This review can also find the most relevant issues in the Scite database and the authors that had the most significant impact and identify the scientists' main lines of research in each defined period.

Keywords: Laser devices, Zinc-tellurite glasses, Rare earth elements.

1.0. INTRODUCTION

Laser devices play a crucial role in various medical applications due to their precision, versatility, and ability to deliver controlled energy to target tissues (Anashkina, *et al* 2013; Bell,*et al* 2014). They are widely used in surgery, dermatology, ophthalmology, dentistry, and other specialties. Laser technology enables minimally invasive procedures, precise tissue ablation, coagulation, and photochemical interactions, making it indispensable in modern medicine for diagnostics, treatment, and research (Denker., *et al* 2020).

Laser devices can improve with improvement in the glass used to produce it. Zinc tellurite glasses are a type of chalcogenide glass known for their infrared transparency and high refractive index

(Dolhen., *et al*. 2018). They consist of zinc oxide (ZnO) and tellurium dioxide (TeO_2) as the main constituents, with additional modifiers such as alkali and rare-earth elements. These glasses exhibit excellent optical properties, including high transmission in the mid-infrared region, low phonon energies, and good chemical stability. These properties make zinc tellurite glasses attractive for various optical applications, including fiber optics, infrared sensing, and laser devices.

Doping of rare earth elements such as erbium and neodymium, can improve the property of a glass (Bell,*et al* 2014).doping a rare earth such as Neodymium (Nd) involves incorporating neodymium ions (Nd^{3+}) into the host material, such as zinc tellurite glasses, to modify their optical properties for laser applications. Neodymium is a rare-earth element known for its ability to produce laser emission in the near-infrared region (~1.06 μm) when pumped with an appropriate light source. The presence of Nd ions introduces energy levels within the host material's bandgap, allowing for stimulated emission when stimulated by an external light source. Neodymium-doped zinc tellurite glasses exhibit characteristics desirable for laser applications, including high gain, broad absorption bands, efficient emission, and tunable output wavelengths (Dolhen., *et al* 2018).

2. 0 **METHODS**

The methodology employed in this review utilizes a descriptive approach and employs bibliometric analysis of metadata obtained from the Scite database (www.scite.ai). The selection of this database is based on three specific criteria. Firstly, the use of Smart Citations within Scite allows for the identification of key studies in the relevant field, providing information on how each paper has been cited, thereby aiding in the assessment of its significance and reliability. This feature is particularly valuable for systematic reviews, where the quality of sources directly influences the credibility of the review. Secondly, the Scite report feature enables a detailed examination of the citation context surrounding a paper, facilitating a deeper understanding of how it has been received within the academic community. This aspect assists in the selection of the most impactful studies for inclusion in the review. Lastly, the Scite Assistant tool offers real-time insights while browsing through articles on the platform, highlighting essential citation information to support informed decisions regarding the inclusion or exclusion of studies

The methodology comprised five distinct stages.

Fig. 1. Five stages of carrying out a meta study

2.1 Defining search key

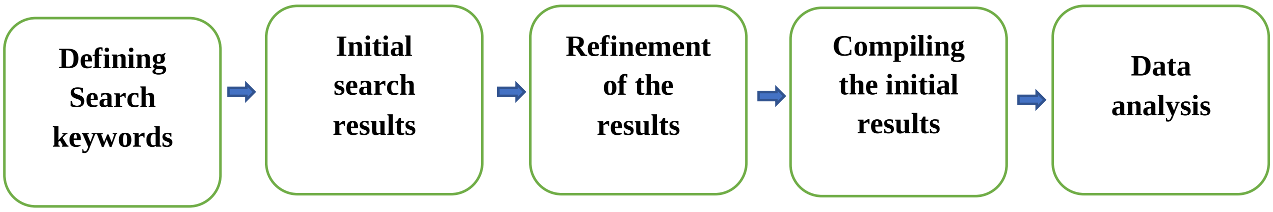
The search key is "Optical" AND "thermal" AND "structural properties of tellurite based" OR "zinc tellurite glasses doped with neodymium for laser applications" with a year limit between 2014-2024. This search key aims to identify research articles and reviews specifically related to the optical and thermal properties of tellurite based or zinc tellurite glasses for laser applications published within the specified time frame.

2.2 Initial search results

The initial search yielded 82,812 documents through data mining. Subsequently, the search results were refined by filtering for articles and reviews in relevant journals, resulting in 657 documents that are more closely aligned with the research focus.

2.3 Refinement of the search

From these, 22 documents were selected for further processing. Data analysis was then conducted descriptively on the initial 82,812 documents to determine document types, sources, affiliations, subject areas, research citations, authorship, and keywords.



2.4 Data Analysis

The top 5 cited articles, top 5 most relevant articles, methods for glass production and characterization, and theories employed by researchers for lasing parameters calculations were reviewed based on the findings. Statistical data was then supported by further analysis through *.ris* files using Microsoft Excel to make the data obtained more detailed

3.0 RESULTS AND DISCUSSION

3.1 Year-wise distribution

The distribution of research publications on properties of zinc tellurite glasses doped with rare earth ions over the years can be seen in Figure 2. It can be seen that the development of these research started around the early 1970s and did not gather significant attention until the mid-2000s, there was an exponential since then. This finding shows that this research has relatively increased every year, especially in the last five years. Therefore, it is predictable that the research and application of Zinc-Tellurite based glasses.

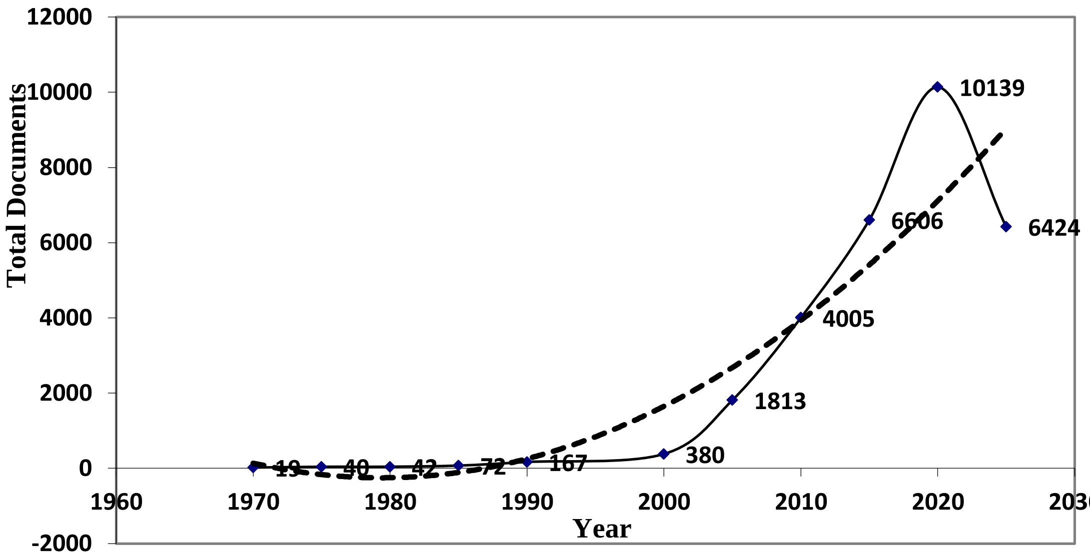


Fig. 2. The trend of research on properties of zinc-tellurite glasses based on the total document per year.

3.2 The Top Ten Authors from Scite Database (www.Scite.ai)

Fig. 3 shows the top authors on research properties of zinc-tellurite glasses for laser application. While Fig. 6 shows top ten sources of scientific research publication on properties of zinc-tellurite glasses for laser application. All of this information can be used as a reference for researchers who focus on the research in this particular field, when looking for accurate and reliable references. Authors who have a large number of documents can be traced, their work can be studied in depth or as reference material for comparison when other researchers develop research in the field of properties of zinc-tellurite glasses for laser application. The sources of scientific publications are listed in Fig. 5. These top ten sources of scientific publications can also be used as a reference when conducting scientific searches, or as a publication destination for researchers in this field.

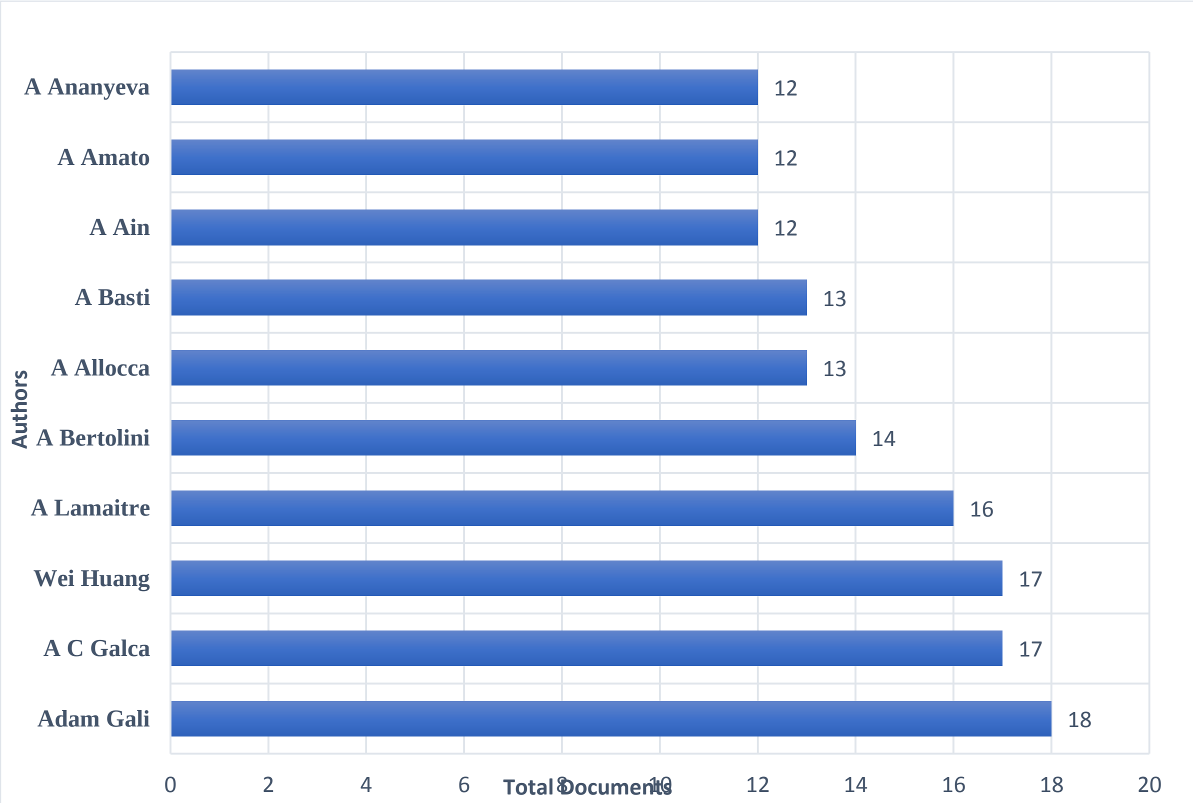


Fig. 3. The top ten authors on the research of properties of zinc-tellurite glasses

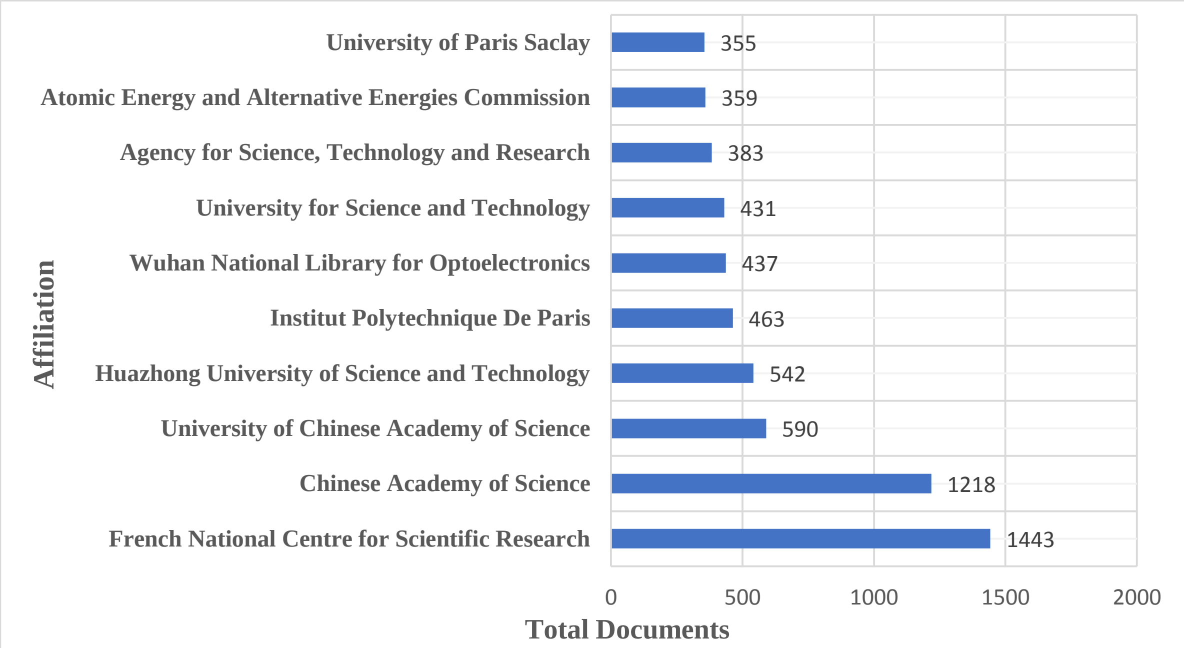


Fig. 4. The top ten authors affiliation on the research of properties of zinc-tellurite glasses.

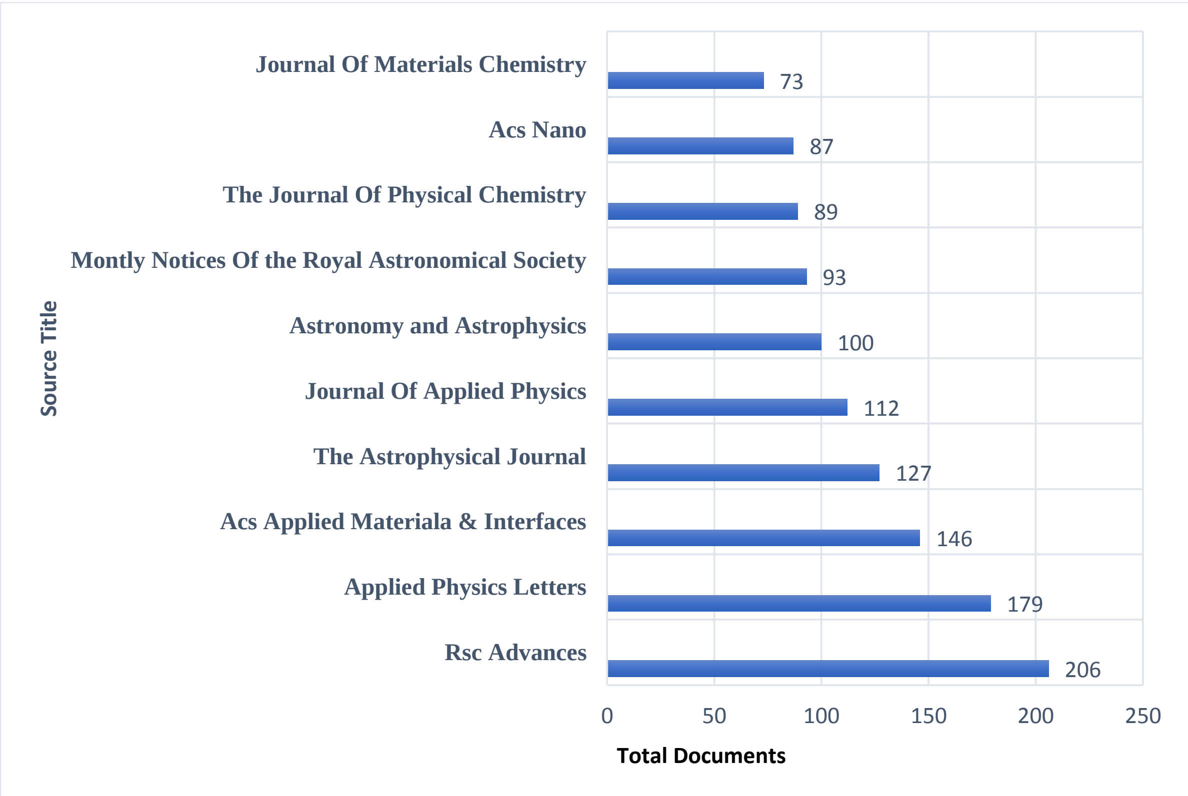


Fig. 5. The top ten publication source on the research of properties of zinc-tellurite glasses.

3.3 Review of top 5 cited publications on zinc-tellurite glasses for laser application

The review was conducted on the top 5 publications cited as impactful studies on zinc-tellurite glasses for laser application research during the last ten years, as shown in Table 1. Each article was analyzed based on the research gap in the article. The majority of the top-cited articles discussed "properties (structural, thermal and optical) of tellurite based glases)".

Based on the top-cited author, Anthony *et al.*, (2016) is recognized as the author with the most citations on zinc-tellurite glasses for laser application research over the last ten years, namely 50 citations and the least is Abdulbaset *et al (*2017) with 21 citations as shown in Table 1.

Table 1: Top 5 most cited authours

Authors	**Title**	**Number of Citation**
Anthony *et al.,* (2016)	Scalable and Formable Tellurite- Based Transparent Ceramics for Near Infrared Applications.	56
Bell *et al.,* (2014)	Laser emission of a Nd-doped mixed tellurite and zinc oxide glass.	40
Dolhen *et al.,* (2018)	Nd^{3+}-doped transparent tellurite ceramics bulk lasers.	26
Costa *et al.,* (2017)	High $Nd^{3+} \rightarrow Yb^{3+}$ energy transfer efficiency in tungsten- tellurite glass.	24
Abdulbaset *et al (*2017)	Effect of Neodymium ions on Density and Elastic Properties of Zinc Tellurite Glass System.	21

3.4 The Judd-Ofelt Theory

The Judd-Ofelt theory has been widely utilized by researchers to assess the optical properties of glasses, particularly in the context of their potential applications as laser systems and amplifier materials (Brito et al., 2007). This theory has been instrumental in the calculation of radiative lifetimes and stimulated emission cross-sections for specific transitions in glasses, thereby contributing to the understanding of their spectroscopic properties (Weber et al., 1981). Additionally, the Judd-Ofelt intensity parameters have been derived from absorption spectra to gain insights into the spectroscopic behavior of doped glasses (Yang et al., 2003).

Table 2: Some authors that utilized J-O for lasing parameter calculations

Authors	**Title**
Muhammad et al., (2024)	Judd Ofelt analysis of zinc tellurite glass doped with neodymium nanoparticles
Josivinir et al., (2021)	Random laser emission from neodymium doped zinc tellurite powder presenting luminescence concentration quenching
Bell *et al.,* (2014)	Laser emission of a Nd-doped mixed tellurite and zinc oxide glass

Muhammad et al. (2024) conducted a study titled "Judd Ofelt analysis of zinctellurite glass doped with neodymium nanoparticles." This research is particularly relevant as it directly addresses the application of the Judd-Ofelt theory in the analysis of optical parameters in neodymium-doped zinctellurite glass. By incorporating the findings from this study, you can provide a comprehensive analysis of the Judd-Ofelt parameters and their implications for the optical properties of the doped glass.

Josivinir et al. (2021) investigated "Random laser emission from neodymium doped zinc tellurite powder presenting luminescence concentration quenching." This study is valuable for understanding the luminescence behavior and concentration quenching effects in neodymium-doped zinc tellurite powder. By incorporating this research, you can explore the relationship between the Judd-Ofelt parameters and the observed random laser emission, thereby enhancing the understanding of the optical properties of the doped material.

Bell et al. (2014) published a study on the "Laser emission of a Nd-doped mixed tellurite and zinc oxide glass." This research is significant as it provides insights into the laser emission characteristics of neodymium-doped mixed tellurite and zinc oxide glass. By referencing this study, you can enrich your thesis with a comprehensive analysis of the Judd-Ofelt theory in the context of laser emission properties and its relevance to the optical characterization of the doped glass

The procedure for the Judd-Ofelt is presented in the flow chat shown in figure below. This figure show the steps all the intensity calculations.

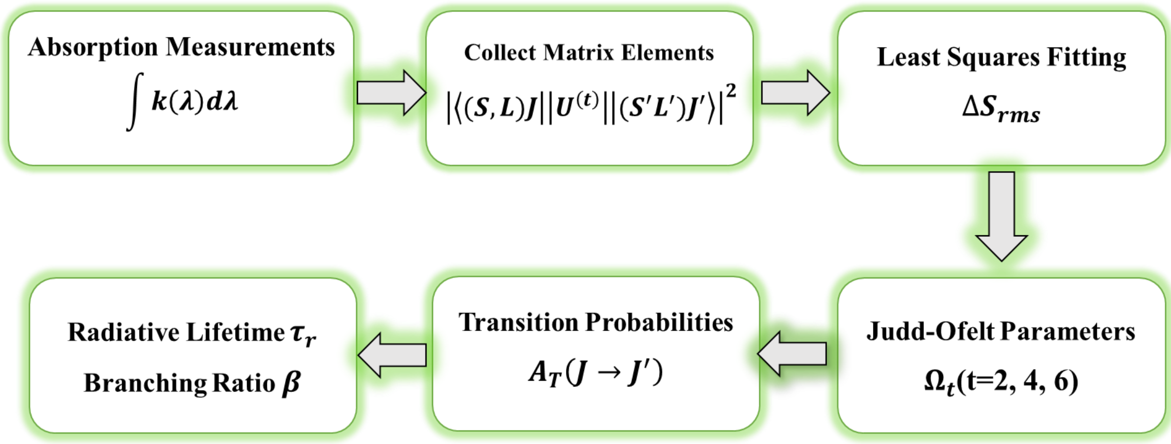


Fig 6. Summery of Judd-Ofelt Theory

3.5 Glass Preparation

The production of glass involves various techniques, including the traditional method of preparing spherical glass balls and polishing them to truncate a part of the sphere (Kishi et al., 2006). Additionally, the fabrication techniques for bioactive glasses include traditional melting methods and sol-gel techniques (Mezahi et al., 2013). Furthermore, the hydrothermal hot-pressing technique has been utilized for preparing porous glasses from CRT TV glass, involving the treatment of glass particles in the presence of aqueous solvents (Matamoros-Veloza et al., 2008).

3.5.1 Quenching Method

The quenching method is a crucial technique in the preparation of glasses, particularly for achieving amorphous structures and unique properties. Conventional rapid quenching techniques such as melt-quenching, shock-wave quenching, and J-quenching have been employed to achieve the high undercooling required for glass formation (Chao et al., 2005; Cai et al., 2015; Sreenivasu & Chandramouli, 2000). Additionally, the use of the melt-quenching technique offers the advantage of using conventional systems and allowing a high flexibility of composition, facilitating the production of glasses with special properties (Cai et al., 2015). Furthermore, glasses have been prepared by quenching the melts in air at room temperature, demonstrating the versatility of quenching methods in glass fabrication (Barde & Nemade, 2022). The utilization of the melt quenching technique has been documented by several researchers, as indicated in Table 3. These studies underscore the widespread application of the melt quenching method in various research endeavors, highlighting its significance in the field of glass preparation.

Table 3: Some authors that used the quenching method for glass preparation

Authors	Research gap	Findings
Song et al. (2023)	highlighted the importance of the liquid phase of metal-organic frameworks (MOFs) in the preparation of melt-quenched bulk glasses	They emphasized that only a few MOFs can be melted and transformed into stable glasses, underscoring the significance of the melt-quench process in glass formation
(Elisa et al., 2020)	a new zinc phosphate-tellurite glass for magneto-optical applications was prepared using a wet method	This research demonstrated the effectiveness of the melt-quench method in producing glass materials suitable for specific applications.
Flenner & Fullerton (2019)	investigated the front-mediated melting of isotropic ultrastable glasses using a combination of swap Monte Carlo and molecular dynamics simulations	This study provided insights into the preparation and melting of isotropic amorphous films with high kinetic stability, showcasing the versatility of the melt-quench technique.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This review examined the top-cited publications on properties of zinc-tellurite glasses for laser devises research during the last ten years using the Scite.ai database. This field has become one of the research interests that has experienced significant development and improvement and the development of technology and the industrial revolution. There are five conclusions in this study as follows: The development of zinc-tellurite glasses research has increased exponentially over the last ten years. The most sponsored funding is the National Natural Science Foundation of China and the National Science Foundation (5). In the top source title, "Rsc Advances" is the main source of the research publications (206). The top authors affiliation on the research of properties of zinc-tellurite glasses is the French National Centre for Scientific Research. For the top-cited author, Anthony *et al.,* (2016) is recognized as the most citated author (56). The author with the highest number of publications is Adam Gali (18) The implication of this research is to find some examples of novelty in zinc-tellurite glasses for laser devises research so that this study can be used as a reference for future research. This research can also find the most relevant issues in the Scite database and the authors that had the most significant impact and identify the scientists' main lines of research in each defined period. Thus, it also contributes to limiting the next trend that can be developed in this research area.

4.2 Recommendations.

i Therefore, researchers can conduct studies on these aspects because they have a high citation rate and impactful studies.

ii Further research on properties of zinc-tellurite glasses for laser devises and publications in high impact journals is recommeneded

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