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A Systematic Review: Trend Research of Polymer Thin Film Dosimetry

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Abstract: The application of polymer dose gels is limited by the sensitivity of dose readout methods and dose gel properties. It is a challenge to find suitable dosimeters for registration of doses delivered to the target by orthovoltage therapy units. The application of metal-particle-enriched polymer composites for dose registration in X-ray therapy might be an elegant solution, especially if recent dose-reading technologies exploring advantages of different physical phenomena are involved. This research aims to identify and analyze research trends of Polymer thin film dosimeters. This research method is descriptive and analytical. The data used in this research was obtained from documents indexed by Google Scholar from 2016-2025 using Publish or Perish and Dimension.ai. Research procedures use PRISMA guidelines. The data identified and analyzed are the type of publication, publication source, and the title of research Polymer thin film dosimeters that is widely cited. The data analysis method uses bibliometric analysis assisted by VOS viewer software. The results of the analysis show that research trend indexed by Google Scholar from 2016 to 2025 has experienced ups and down. There are many documents in the form of articles, chapters, proceeding, monograph, preprint, and edited books that discuss research into the polymer thin film dosimetry. Key words that are often used in research about it are Gamma radiation dosimetry, Polyvinyl alcohol, PVA, TeO_2, ZnO, Polymerization, etc.

Keywords: Dosimetry; Polymer; Radiation; Thin film.

Introduction

Dosimeters from various materials have been intensively studied as devices to monitor radiation doses (Gafar et al., 2017). Dosimeters of colored thin-film polymer materials have been extensively developed for measuring the adsorbed radiation dose by materials, and have been applied in routine dosimeters (Kattan et al., 2011). The main technical advantage of a polymer film-based dosimeter as a radiation detector is its slightness and portability (Akhtar et al., 2016). In addition, the film has a long storage stability, is sturdy, and is cost-effective (Akhtar et al., 2013). Some of the applications of film dosimeters include: routine high-dose radiation to food and beverages (El-Kelany & Gafar, 2016); sterilization process (Gafar & El-Ahdal, 2014); radiotherapy in medical field (Aydarous et al., 2016; Basfar et al., 2012; Hassani et al., 2014); and dye dosimeters (Omer & Bashir, 2018).

Radiation dosimetry is used to measure the absorbed radiation dose, or determine the incident radiation on a material (Rabaeh et al., 2021). Therefore, it is necessary to ensure the accuracy of the radiation dose (Hosni et al., 2013). Many materials have been developed and explored as radiation dosimetry, evaluated under different dose ranges (Abdel-Fattah et al., 2014; Soliman et al., 2018; Ticoş et al., 2019). A film-based radiation dosimetry can be developed from a

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mixture of polymers, with a dye as indicator. The polymer materials that have been explored include polyvinyl alcohol (PVA) (El-Kelany & Gafar, 2016; Raouafi et al., 2018) polycarbonate (Galante & Campos, 2012); polyvinyl chloride (Kattan & Daher, 2016); and polyvinyl butyric (Abdel-Fattah et al., 2014). Meanwhile, coloring materials as indicators include: methylene blue and methylene red (Akhtar et al., 2013); thymolphthalein (TP) (El-Kelany & Gafar, 2016); ethyl violet and blue bromophenol (Ebraheem et al., 2002); cresol red (CR) (Ebraheem & El-Kelany, 2013); tetrazolium violet (Emi-Reynolds et al., 2007); and methyl viologen (Lavalle et al., 2007).

PVA based polymer materials are most recommended because they have a high degree of flexibility (Ang et al., 2020), are water-soluble (Wong et al., 2020), have good mechanical properties, and are non-toxic and elastic (Chaturvedi et al., 2015). PVA has been combined with several mixed dyes (tetrabromo phenolphthalein ethyl ester, acid yellow, and chloral hydrate) and has shown promising prospect as a new dosimeter in the 0.1 to 5 kGy dose range (Gafar et al., 2017). PVA with TP dye is effective as a new detector system for application at doses of 1 to 6.5 kGy (El-Kelany & Gafar, 2016), and PVA with methyl thymol blue dye showed some efficacy under a dose range from 2.5 to 20 kGy (Rabaeh et al., 2021).

Several blends of chlorine-containing polymer have been investigated for possible use for dosimetry of γ-rays radiation and electron beams (Abdel-Fattah et al., 1996, 1997). They also contain dye as pH indicators, and the presence of chlorine improves the water solubility. For instance, a mixture of dehydrochlorines and an acid has a low pH. The low pH increases the sensitivity of the dye component to change color.

Therefore, this research wants to know the research trend of the Polymer thin film dosimeters. It is hoped this research can become a reference in developing further research related to Polymer thin film dosimeters.

Method

This research method is descriptive and analytical, which aims to understand and describe research trends in the Polymer thin film dosimeters. The data used in this study was obtained from information sources indexed by Google Scholar using analytical tools such as Publish or Perish and Dimension.ai.

In this research, an analysis was carried out on 1,000 documents that had been indexed by Google Scholar between 2016 and 2025. The Google Scholar database was chosen as a place to search for documents because Google Scholar applies consistent standards in selecting documents to be included in its index, and Google Scholar displays more documents than the top databases. Others, especially research in the field of education (Hallinger & Chatpinyakoop, 2019; Hallinger & Nguyen, 2020; Zawacki-Richter et al., 2019). To filter data that has been collected via Publish or Perish, researchers used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Result and Discussion

This research aims to describe research trends on the Polymer thin film dosimeters conducted from 2016 to 2025. Figure 1 shows that the trend in research on the Polymer thin film dosimeters from 2016 to 2025 experiencing ups and downs.

The most publications occurred in 2024, namely 717 publications. This proves that research about Polymer thin film dosimeters is tends to increase until last year. Below are also table 1 presented research of Polymer thin film dosimeters based on the type of publication.

Table 1. Trends in Polymer thin film dosimeters Research Based on Publication Types

Publication Type	Publications
Article	6,980
Chapter	3,301
Edited Book	1,837
Monograph	575
Proceeding	267
Preprint	73

Based on Table 1, it is known that research Polymer thin film dosimeters from 2065 to 2025 contained in 6 types of publications. In the form of articles there were 6,980 documents, edited books 1,837 documents, chapter as many as 3,301 documents, monograph 575 documents, preprint 73 documents and also 267 documents from proceeding. Research trends Polymer thin film dosimeters in article form is the type of publication that contains the most research compared to other types of publications. Meanwhile, the type of publication contains the least amount of research results is a preprint. Research conducted by Oltarzhevskyi (2019) states that an article is a complete factual essay of a certain length created for publication in online or print media (via newspapers, magazines or bulletins) and aims to convey ideas and facts that can convince and educate. These articles are usually published in scientific journals both in print and online (Suseno & Fauziah, 2020).

Below are also table 2 presented top sources title trends in research on Polymer thin film dosimeters which are often cited by other researchers related to this matter. Table 2 shows that the most widely published source of research trends on the Polymer thin film

dosimeters is the Epidemiology, namely 1,125 publications with 884 citations and an average citation of 0.79. Epidemiology publishes original research from all fields of epidemiology. The journal also welcomes review articles and meta-analyses, novel hypotheses, descriptions and applications of new methods, and discussions of research theory or public health policy. Below are also table 3 presented top article title trends in research on Polymer thin film dosimeters which are often cited by other researchers related to this matter.

Table 2. Top Sources Title Trend of Polymer thin film dosimeters Research in 2016-2025

Name	Publications	Citations	Citations Mean
Epidemiology	1,125	884	0.79
Critical Care	518	405	0.78
Radiation Physics and Chemistry	340	5,032	14.80
Medical Physics	328	7,459	22.74
Physics in Medicine and Biology	108	5,045	46.71
Radiation Measurements	97	1,324	13.65
Applied Radiation and Isotopes	96	1,076	11.21
Proceedings of SPIE--the International Society for Optical Engineering	75	301	4.01

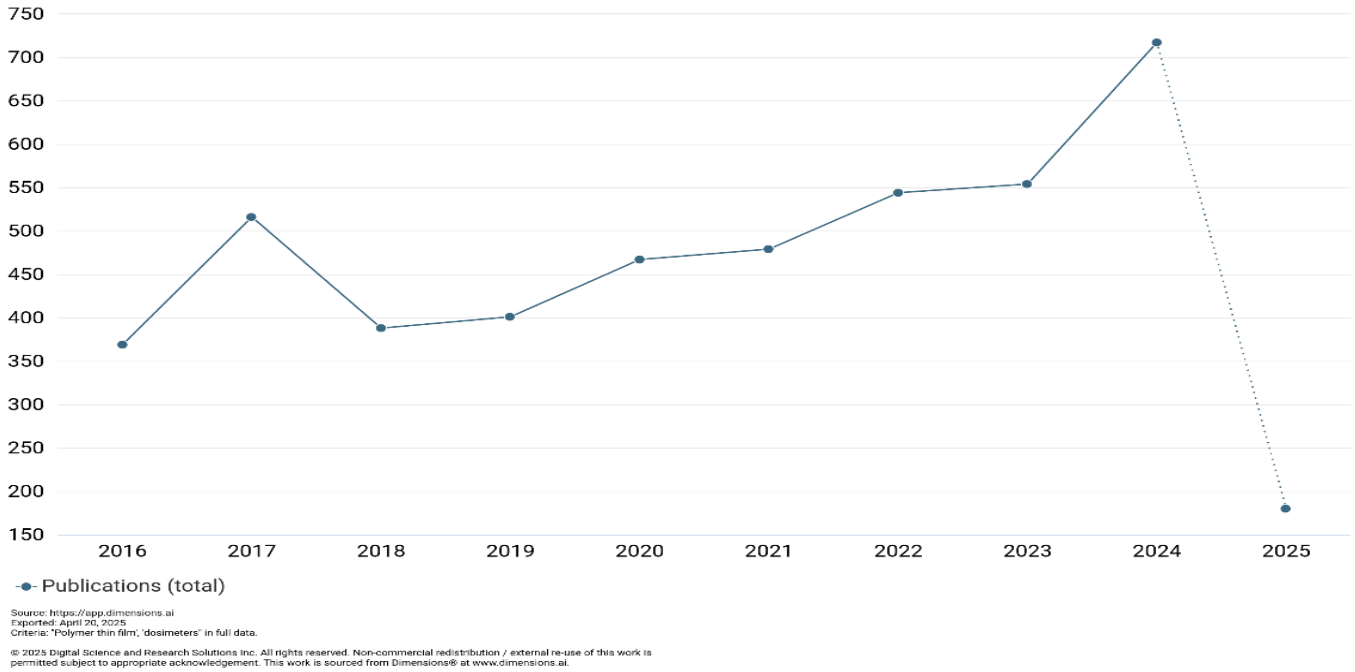

Figure 1. Research trends in Polymer thin film dosimeters

Table 3. Top Citations on Trend of Polymer thin film dosimeters Research in 2016-2025

Cites/year	Year	Author	Title
43.67	2016	Slobodan Devic, Nada Tomic, David Lewis	Reference radiochromic film dosimetry: Review of technical aspects
12.13	2017	Y Watanabe, L Warmington, N Gopishankar	Three-dimensional radiation dosimetry using polymer gel and solid radiochromic polymer: From basics to clinical applications
7.75	2021	Aris Doyan et al	Polymer Film Blend of Polyvinyl Alcohol, Trichloroethylene and Cresol Red for Gamma Radiation Dosimetry
3.80	2020	Diana Adliene, Benas Gabrielis Urbonavicius, Jurgita Laurikaitiene, Judita Puiso	New application of polymer gels in medical radiation dosimetry: Plasmonic sensors
3.00	2021	Saleh alashrah et al	Development, Characterization and Valuable Use of Novel Dosimeter Film Based on PVA Polymer Doped Nitro Blue Tetrazolium Dye and AgNO3 for the Accurate Detection of Low X-ray Doses
1.00	2024	Alfio V. Parisi et al	Ultraviolet radiation thin film dosimetry: A review of properties and applications

Table 3 shows that research on the Polymer thin film dosimeters that is widely cited by other researchers is about "Reference radiochromic film dosimetry: Review of technical aspects" which is 43.67 (Devic et al., 2016). Then the research entitled "Three-dimensional radiation dosimetry using polymer gel and solid radiochromic polymer: From basics to clinical applications" was cited 12.13 times (Watanabe et al., 2017). Research by Doyan et al. (2021) entitled "Polymer Film Blend of Polyvinyl Alcohol, Trichloroethylene and Cresol Red for Gamma Radiation Dosimetry" is also widely cited by other researchers, namely 7.75 per year.

This research data is comparable to data on the increasing trend of research on the Polymer thin film dosimeters from 2016 to 2025. This means that in that year, research related to it was continuously cited by other researchers. In the articles researched and written by these researchers, there are many terms/keywords related to Polymer thin film dosimeters. Below are presented the most popular keywords related to Polymer thin film dosimeters.

Table 4. Keywords on Trend of Polymer thin film dosimeters Research in 2016-2025

Terms	Occurrences	Relevance
Gamma radiation dosimetry	3	9.05
Polyvinyl alcohol	3	9.05
PVA	6	2.04
TeO_2	4	1.15
ZnO	5	0.94
Polymerization	4	0.59

Table 4 shows that the keywords that often appear related to research on the Polymer thin film dosimeters are gamma radiation dosimetry, 3 times with a level of 9.05. Table 4 also shows that polyvinyl alcohol is also one of the keyword that appears frequently in research trends on the Polymer thin film dosimeters, namely 3 times with a relevance of 9.05.

Below are the visualization is accomplished by generating a landscape map, which offers a visual representation of subjects related to scientific studies. The outcomes of bibliometric mapping for the co-word network in articles related to the topic Polymer thin film dosimeters are illustrated in Figure 2.

Figure 2 shows the results of bibliometric keyword mapping on research trends on the Polymer thin film dosimeters. In Figure 2 there are 49 keyword items that are often used in research on the Polymer thin film dosimeters from 2016 to 2025. Figure 2 also contains 7 clusters, where the first cluster is colored red and consists of 8 keyword items, namely fabrication, polyvinyl alcohol, etc. The second cluster in green consists of 8 keyword items, namely polymer gel, TeO_2, ZnO, etc. The third cluster in blue consists of 7 keyword items, namely optical property, polymer chain, etc. The fourth yellow cluster consists of 7 keyword items, namely film dosimeter, radiation, etc. The fifth cluster consists 7 items, namely characterization, PVA polymer, etc. And the sixth and seventh cluster each consist of 6 items.

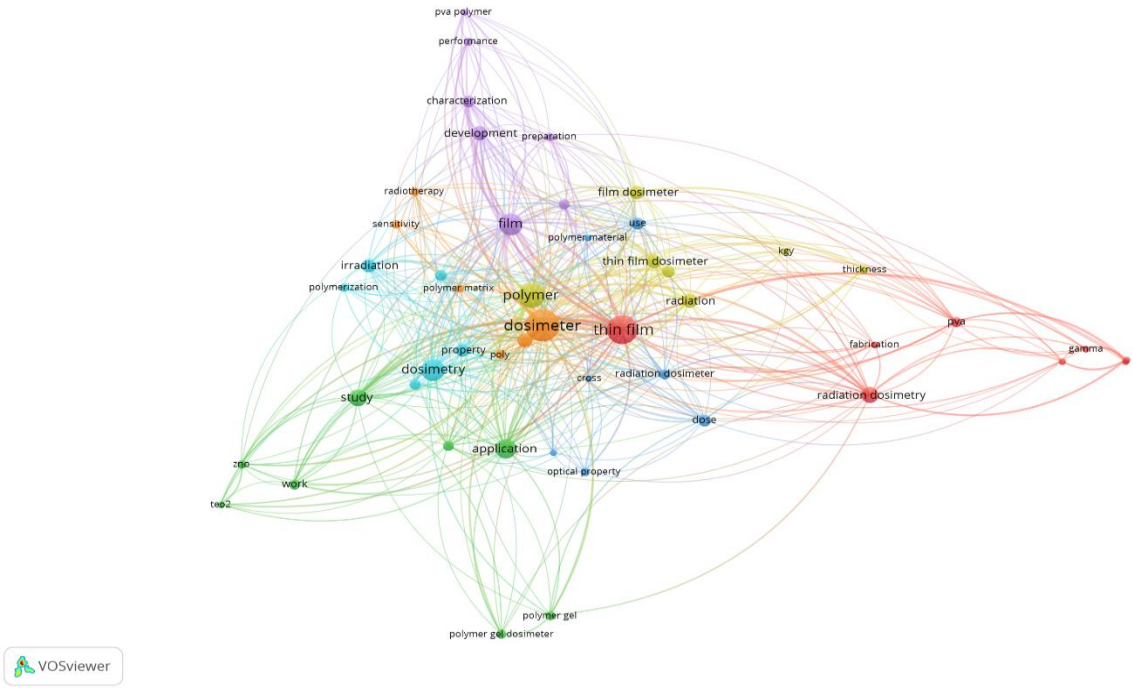

Figure 2. Network visualization on trend Polymer thin film dosimeters research

Figure 2 above also shows that network visualization shows the network between the terms being visualized. Keywords classified into four clusters are arranged in a color chart showing the divisions/clusters that are connected to each other. The results of this analysis can be used to determine keyword research trends in the last year. This analysis shows several keywords that are often used in research on the Polymer thin film dosimeters. The more keywords that appear, the wider the visualization displayed. Below are also presented keywords regarding the Polymer gel dosimeters based on overlay visualization.

Figure 3 shows the trend of keywords related to Polymer thin film dosimeters in Google Scholar indexed journals from 2016 to 2025. Trends in the themes of writing articles related to Polymer thin film dosimeter from the oldest to the newest year are marked with purple, blue themes, turquoise, dark green, light green and yellow. In the picture below you can see that radiochromic film, polymer matrix, polymerization, etc. This shows that these keywords were widely used by researchers in 2019. But in 2022, the keywords that frequently appeared were PVA polymer, ZnO, TeO_2, gamma radiation dosimetry, etc.

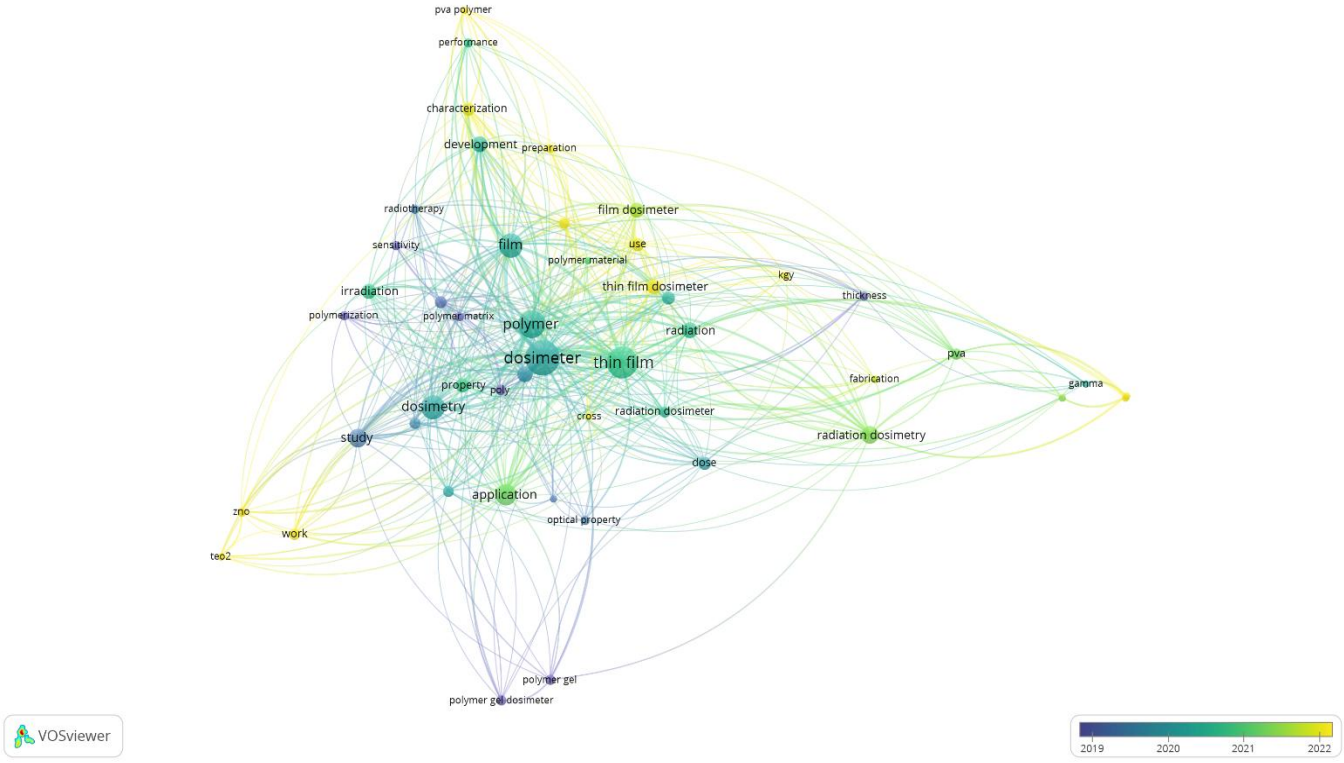

Figure 3. Overlay visualization on trend Polymer thin film dosimeters research

Research on Polymer thin film dosimeters is one area of research that has developed rapidly in recent years. The following also presents keywords for Polymer thin film dosimeters research based on density visualization.

Figure 4 shows density visualization. The density of research themes is shown in bright yellow. The brighter the colors of a theme, the more research is done. The fainter the color means the theme is rarely researched (Kaur et al., 2022; Liao et al., 2018). Faintly colored themes such as dosimetry system, optical property, fabrication are dimly colored keywords. This shows that these keywords can be used as a reference for further research. Doyan et al. (2023) and Bahtiar et al. (2023) stated that yellow indicates keywords that are currently and frequently used in research, like polymer, dosimeter, thin film, etc.

Overall, Polymer gels and films, due to their near equivalence to biological tissue, are amongst the most promising future dosimetry tools for medical applications. The application of polymer dose gels is limited by the sensitivity of dose readout methods and dose gel properties. It is a challenge to find suitable dosimeters for registration of doses delivered to the target by orthovoltage therapy units. The application of metal-particle-enriched polymer composites for dose registration in X-ray therapy might be an elegant solution, especially if recent dose-reading technologies exploring advantages of different physical phenomena are involved.

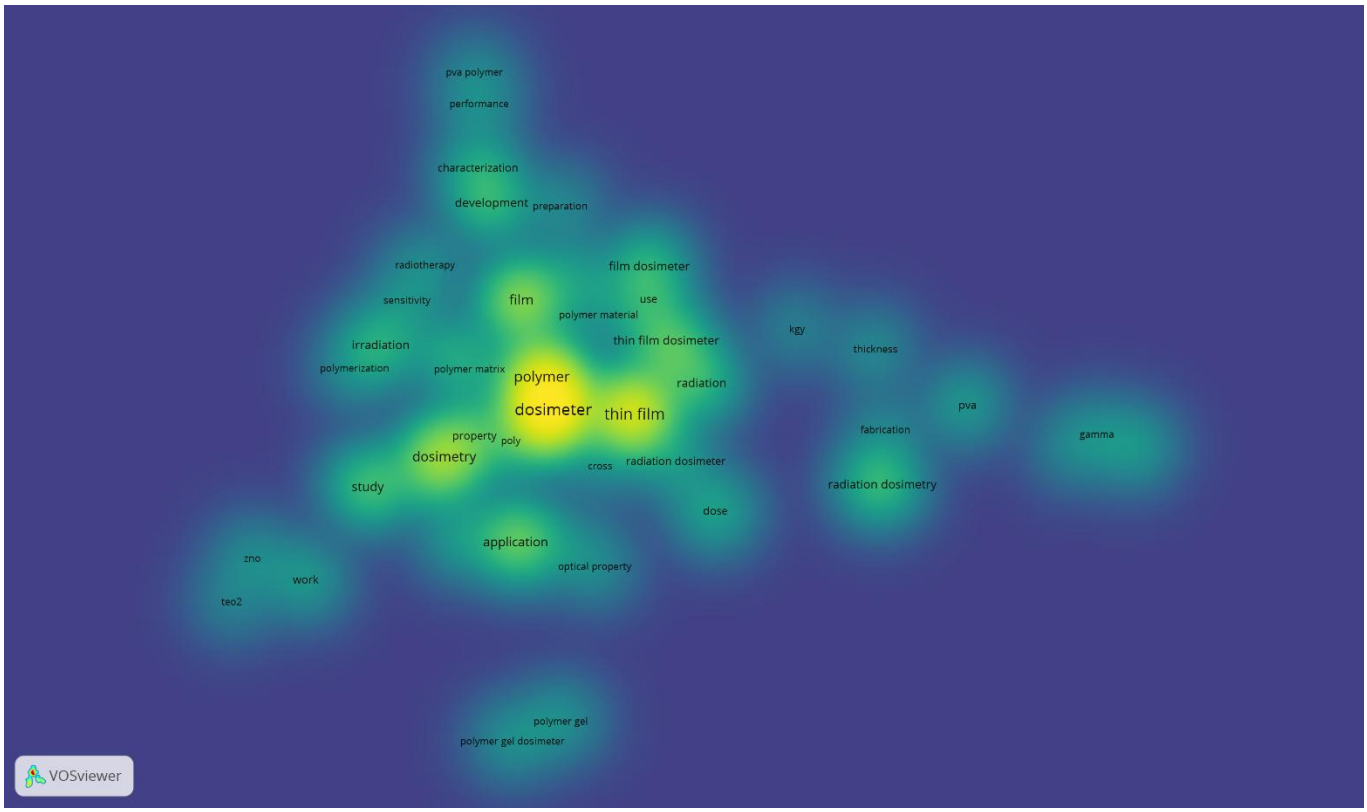

Figure 4. Density visualization on trend Polymer thin film dosimeters research

Research in the field of polymer gel dosimetry covers many different aspects. Several studies have been conducted on the chemistry of the polymer gel and different gel compositions have been proposed. A better understanding of the physical and chemical interactions within the polymer gel dosimeter can help in optimizing the composition to obtain a gel that fulfills the dosimetric criteria and achieves high dose sensitivity. Research in the field of gel dosimetry includes also the development and optimization of quantitative scan techniques. The most promising scan techniques are magnetic resonance imaging and x-ray and optical computerized tomography. For different scan techniques, different optimal gel dosimeters can be found. Optimal gel systems for magnetic resonance imaging display a significant change in NMR relaxation time or magnetization transfer. For x-ray CT, the dose sensitivity is determined by the density change.

Conclusion

Research on trends in the polymer thin film dosimetry has urgency high because it is very useful in the health sector, especially radiotherapy. The research trend on the polymer thin film dosimetry indexed by Google Scholar from 2016 to 2025 has experienced ups and downs. There are many documents in the form of articles, chapters, proceeding, monograph, preprint, and edited books that discuss research into the polymer thin film dosimetry. Key words that are often used in research about it are Gamma radiation dosimetry, Polyvinyl alcohol, PVA, TeO_2, ZnO, Polymerization, etc.

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