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Bibliometric and Visual Analysis of Trends in Cosmetics: A Forensic Approach

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Abstract

In recent years the utilization of cosmetics has exponentiated worldwide, irrespective of the gender. From the perspective of forensics, cosmetics are often found in minute quantities in crime scene. There has been a lot of research conducted on a number of cosmetic products; hence it becomes important to analyze the research trends on cosmetological advancements. The current study focuses on creating a bibliometric and visual analysis, using the software, VOSViewer. All of the studies conducted in the field are from 1972 to 2022. For this, SCOPUS database has been selected to retrieve all the studies that are related to the forensic analysis of cosmetics. Research trends were studied with respect to the publications, citations and co-citations, keywords, countries as well as authors, journals and their impact. Journal analysis was also done by calculating its CiteScore as well as SNIP, SJR and Quartile ranking. Out of the 63 shortlisted studies on the basis of their relevance, it was found that India contributed the most (28.37%) in the field, followed by USA (12.16%). The authors who were cited the most were Rajinder Singh and Vishal Sharma with 17.13% and 13.94% citations respectively. Forensic Science International was the copious as well as most cited journal. Maximum number of studies have been done on lip (38%) and hair (23%) cosmetics. The most utilized analytical technique was found to be mass spectrometry (21%) followed by ATR-FTIR (19%). The cumulative publications have increased significantly from 2014 to 2022. Henceforth, it becomes important to study the research trends of the field. To summarize, the current review studies about all the features of publications like; most dominating countries, co-cited references and keywords, influential authors, journals and trends followed in the field of forensic cosmetics.

Keywords: bibliometric analysis, VOSviewer, cosmetics, research trend

1. Introduction

Cosmetics, in contemporary world have become an inevitable part of everyone`s life. Irrespective of the age and gender, there is a cosmetic product for all. Cosmetics are defined as a product or article, that is used for cleansing as well as enhancement of looks of an individual, to look more beautiful and attractive. The application however can be with the help of rubbing, spraying, sprinkle and so on. There is a cosmetic for almost every aspect of our body [1]. Cosmetics are divided into a number of categories, including hair care, soaps, nail care, skin care, cosmetics for the face, and cosmetics for the body [2].

The colour of cosmetic evidence in forensic cosmetic examination enables speedy separation. It can be done of both; questioned as well as recovered samples, however, when comparable colours are provided, a subjective interpretation becomes necessary. Therefore, instrumental analysis is carried out on cosmetic evidence, with objective outcomes. Cosmetics are divided into a number of categories, including hair care, soaps, oral hygiene, skin care, nail care, and decorative items (makeup) [3,4]. Therefore, cosmetics have a noteworthy impact on forensics, serving as crucial trace

evidence. Their ability to transfer easily to different substrates is a key factor, yet their persistence allows them to remain detectable for an extended period after transfer. Since it cannot be seen with the naked eye, the criminal does not remove or damage it. Another aspect of forensic science is identifying and determining the origin of trace evidence. This could be helpful in finding a link between the suspect, the victim, and the crime scene. Hence it serves as significant corroborative evidence. In cases where the link could not be established, it could then help in the process of exclusion of certain suspects or exhibits. In addition analysis of cosmetics can serve as circumstantial evidence by providing information of the criminal, timeline, and clarify offences in courtroom [5]. In forensics, even the smallest amount of evidence can be extremely important. Cosmetic smudges are a typical form of transfer evidence discovered at crime scenes. The residues may be observed on clothing or bedding because to its propensity for simple transfer and broad usage, especially in cases involving sexual assault [6].

The trace can be obtained from any cosmetic. Small amounts of lipstick are found on garments, cigarette butts, paper, etc. in forensic science labs [7]. Similarly, foundations fall in that category of cosmetics, which is responsible for providing a homogeneity to the texture of skin. Foundations are used for glow as well as to make skin look clearer, smoother etc. Consumers often use them for hiding any imperfections like scar or blemish [8]. Other such products useful in cosmetic examination can be eye cosmetics like kajal [9], eyeliner and mascara [10] [11].

The methods employed in the analysis of these cosmetic samples must be precise and sensitive enough to yield results for even minute traces of evidence. Thin-layer chromatography, although a traditional technique, holds significant importance in conducting such analyses. In the realm of cosmetics, it is primarily utilized for the examination of lipsticks [12,13,14] vermilion [15], etc. Gas chromatography is another critical instrument used for the analysis of lip gloss, which can be useful in detecting the presence of groups like styrene, cyclo-hexane etc. [16]. Additionally, in lipsticks, the technique was employed to observe peaks from lipstick extracted from different substrates [17,18]; enzanthracene, chrysene, benzofluorantene, benzofluorantene, benzopirene, dibenzoantracene; were few other components that could be identified from lipsticks. [19,20,21]. Hair products such as hair sprays and hair growth products, could also be identified from GC. Components like cetyl alcohol and unknown compounds of m/z value 281 and 424 could possibly give the presence of; ethyl myristate, ethyl pulmitate, ethyl oleate and ethtyl stearate [22,23]. Moreover, it has capability to identify foundations [24] and various other cosmetic smudges [25]. Another analytical technique which is widely used for differentiation is FTIR, used for analysis of lipsticks [20]. Several aliphatic and aromatic chemicals, such as silicates and the propyl ester of hexanoic acid, could be identified [26]. Another study identified key analytes, comprising various chemical bonds linked to distinct functional groups in the lipsticks. Noteworthy peaks detected were observed for many functional groups such as OH stretching, NH stretching at 2917.64 cm^{-1}, C–H stretching at 2847.02 cm^{-1} and many more [27]. Eye cosmetics also gave exceptional results from ATR-FTIR including eyeliner and eyeshadows [28]. The ATR-FTIR spectra of kajal samples disclosed specific analytes, with a peak at 3430 cm^{-1} indicating the presence of hydroxyl groups (–OH) within the 3700–3400 cm^{-1} range and olefinic groups, marked by a band at 3015 cm^{-1} along with many other peaks. These distinctive peaks offer insights into the unique chemical composition of the kajal samples [29]. The technique could also be applied for analysis of eyeliner and mascara samples (4000–400 cm^{-1}) detected polyethylene glycol and C–H bonding in aliphatic/aromatic compounds (peaks at 3310 cm^{-1} and 3000 cm^{-1}). Aliphatic C–H bonding was identified at 2954 cm^{-1}, 2916 cm^{-1}, and 2850 cm^{-1} [30]. The same for vermilion gave few peaks like; 4000–2800 (O–H, C–H, and N–H stretching vibrations) corresponding to; water, alcohol, and amide and 1680–1600 (C=C stretching) etc. [31]. Following these, foundations examinations were also carried out by ATR-FTIR by providing peaks at most of the fingerprint region like; 1735 cm^{-1}, 1640 cm^{-1} etc. [32,24], and so on. Furthermore, identification and examination of the products can be utilized by X-rays methods. Specially for the analysis of hair [33], nail polish, providing presence of elements such as; S, Ti, Fe, Cu, Zn and Bi [34,35], foundations [24] and many more. One of the other important analytical techniques can be mass spectroscopy, a quantitative technique mostly hyphenated with other sophisticated method. It could be utilized for samples like; lip cosmetics [16,20] hair [36], perfume [37], nail paint [38] etc. Other than these techniques there are numerous other techniques used for identification and determination of such cosmetic products.

2. Methodology

2.1 Data Extraction and Data Cleaning

In the present study, Scopus database was chosen for extraction of all the related documents. To acquire the related content, it is important to search most suitable range of articles. Henceforth, `forensic AND cosmetic*` was searched in order to get all the related documents. It was meant to include all the articles that contain the above-mentioned term included in the article title, abstract or as a keyword. A total of 390 documents were obtained. These results were further filtered. The process of data cleaning was applied onto the obtained set of documents. The filter was applied was of language and

document type. English was the only language selected for all documents. In addition, articles, conference paper, review paper and book chapters were selected to be included whereas, rest of the documents were excluded. After applying these filters, a total of 357 documents were remaining. From this final selection of documents related to the search were done by individually accepting the suitable document. The final shortlisted documents gave a total count of 67 documents.

2.2 Data Analysis and Representation

VOS viewer (1.6.19) is a visualisation tool, which is useful for making clusters of the given data and hence obtain a network of the same with the help of forming a map of the data. It was utilized in the paper to get proper visualizing results of data from national and international publication.

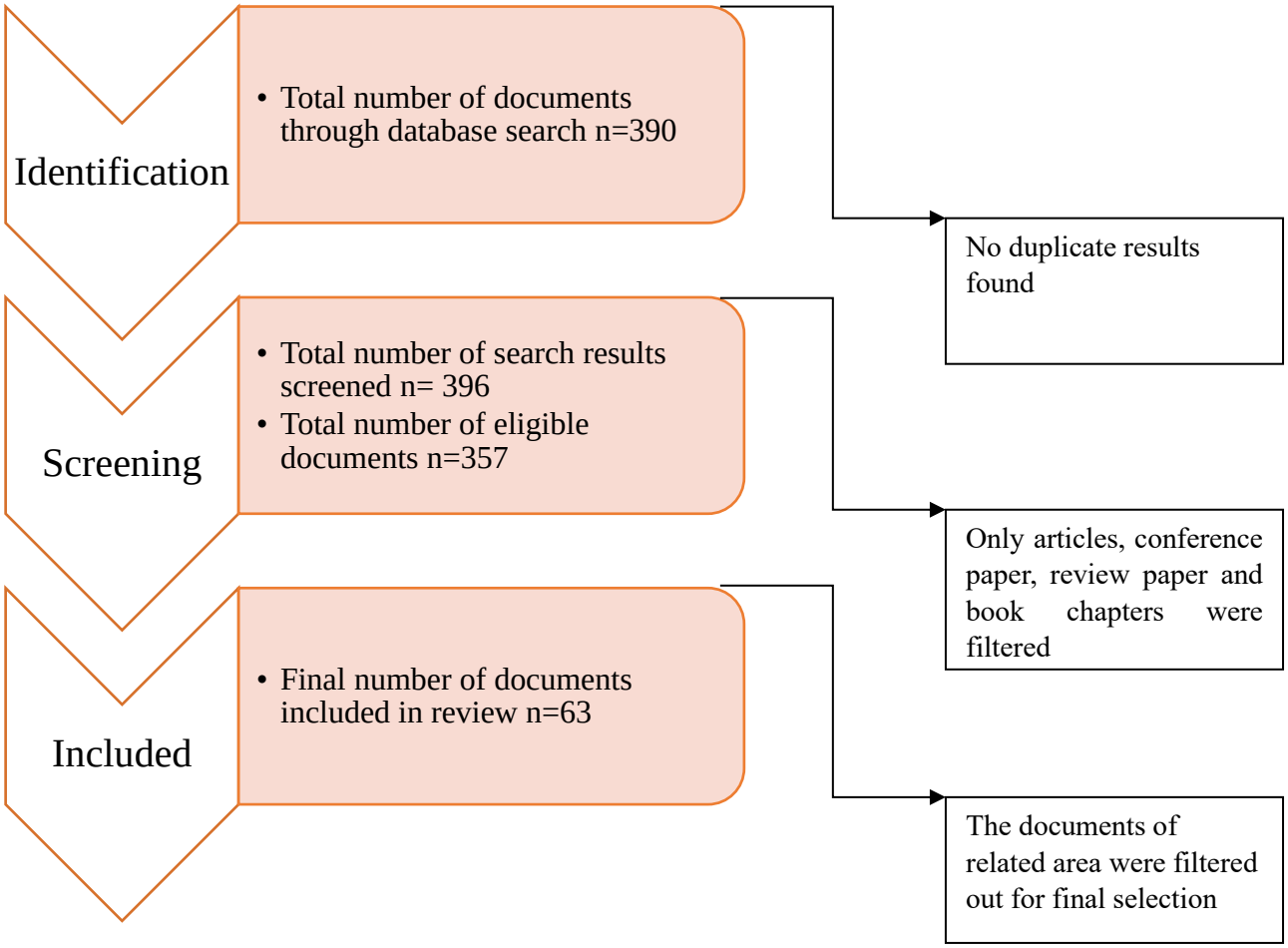

Chart 1: Procedure followed for review according to Prisma [39]

3. Results and discussions

3.1. Overall publications in the field: timeline

As discussed above 67 are the total number of documents were obtained after data cleaning. The first publication related to Forensic cosmetics dated back in the year 1972. The timeline that is considered for review was from 1972-2022. Since the documents published in 2023 remain yet to be cited, therefore, that data is not considered. Then, studies have been conducted on various types of cosmetics and till date there are many papers that have a large number of citations in many reputed journals. After 1972, there was a considerable gap in Forensic research on cosmetics until 1983. Since then, forensic analysis of cosmetics started to grow and papers were published providing studies on different categories of cosmetics. After 2011, an increase in published documents could be observed. The maximum number of documents published were in the year 2022, where a sum of 13 (8.71% of total documents) documents were published in the same year, whereas 2019 had second largest number of publications, i.e., 6 documents were published in the year.

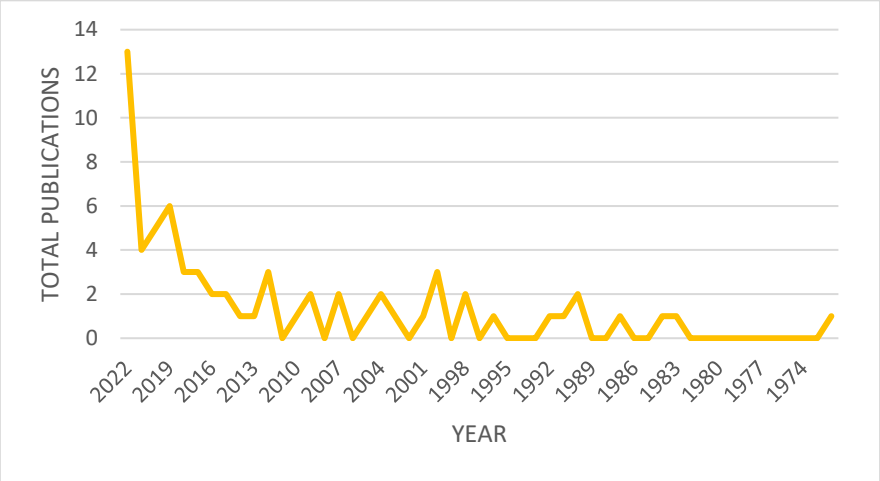

Chart 2: Total number of publications done yearly from [1972- 2022]

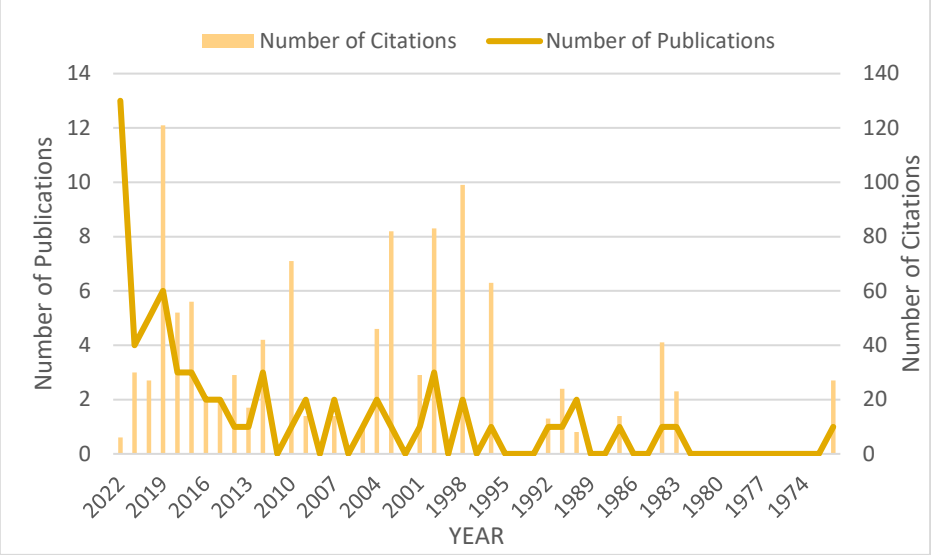

Chart 3 Year-wise publications (primary Y-axis) and citations (secondary Y-axis) of all documents.

3.2. Analysis of country wise contribution in the field

There are about 24 countries that have contributed in the field of cosmetic analysis with respect to forensic science. India has contributed maximum number of publications in the domain. With a total of 21 publications of all the related papers in the field. In comparison, other countries have a very less contribution in terms of number of documents published. The second largest paper publications are from the United States of America. Following US, is Germany with 6 publications, and rest of the countries have publications of less than 5 documents. From the graphical representation it is clear that, even though there are very a smaller number of publications for certain countries, they still have left a great impact with their citations. Germany can be the best example of above statement, as it has a total of 182 citations with 6 documents published. Italy, having just single document published has got 71 citations in it. Similarly, in the case of United Kingdom, total of 3 publications have a total of 122 citations. If the timeline is considered with respect to the countries. In the timeline of years between 2005 to 2022.

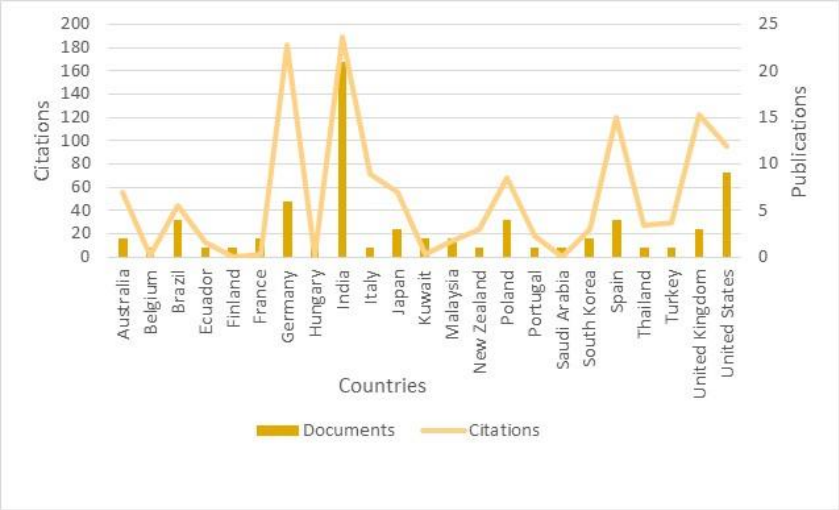

Chart 4: Country-wise citations (primary Y-axis) and publications (secondary Y-axis) of all documents.

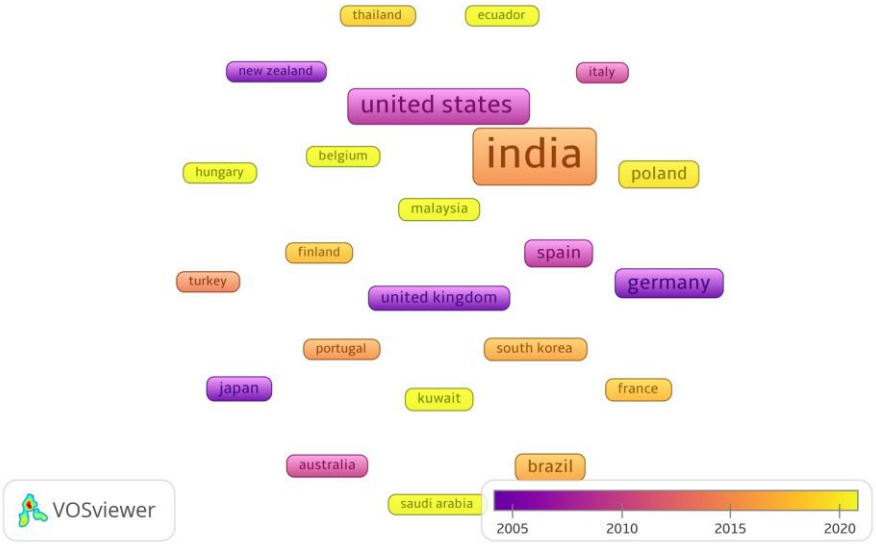

Chart 5: Timeline of countries with their publications

3.3. Most common co-occurred keywords

Co-occurred keywords are commonly used words in more than one research study. It is a typical practice to utilize keyword co-occurrence analysis to pinpoint widely used study areas. The criteria were set that a specific keyword must have co-occurred 5 times. The result showed a total of 33 keywords. After filtering out repetitive or relatable keywords, a sum of 17 keywords were obtained. Out of these the most commonly used terms were ‘cosmetic’, ‘lipstick’ and ‘chemometric analysis’ as most co-occurred words in majority of papers. Out of these keywords, the most co-occurred technique was ‘Fourier transformation infrared spectroscopy’ and for cosmetic product in use was ‘lipstick, followed by hair related cosmetic analysis. The mapping was obtained of these keywords as shown in chart 6. In it 4 clusters were formed showing red cluster being the largest with keywords, chemical analysis, cosmetic, fluorescence, lipstick and Raman spectroscopy. Cluster 2(blue); consisting of chemical analysis, chemometric analysis, discriminant analysis and forensic chemistry. Cluster 3(green) consisted of Fourier Transform Infrared spectroscopy, infrared spectroscopy and trace evidence. Finally, cluster 4 (yellow) represented; gas chromatography, hair analysis and mass spectrometry.

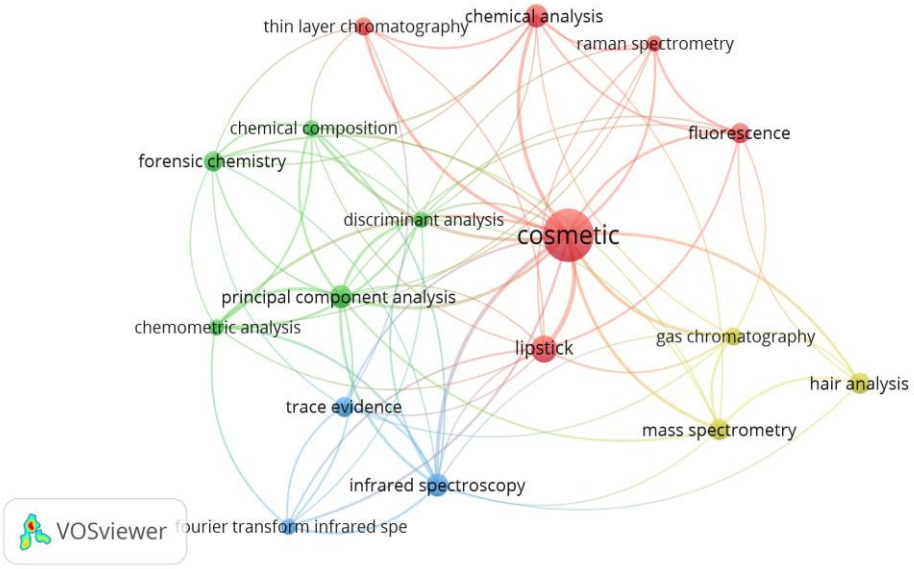

Chart 6: Mapping of keywords that have co-occurred 5 or more times

In addition to the above mapping an overlay mapping wad obtained so as to get the timeline of these keywords, i.e., year range when they were most prevalent. The overall range of year was selected from 2005-2020. As shown in the Chart 7, it could be concluded that, the recently co-occurred words in yellow were 'principal component analysis', 'discriminant analysis', 'Fourier transform infrared spectroscopy' and 'Forensic chemistry'. While, around 2010-2015, 'chemical analysis', 'fluorescence' and 'trace evidence' were in co-occurrence. Keywords; 'cosmetic', 'lipstick', 'gas chromatography' and 'hair analysis were more used in the years around 2005.

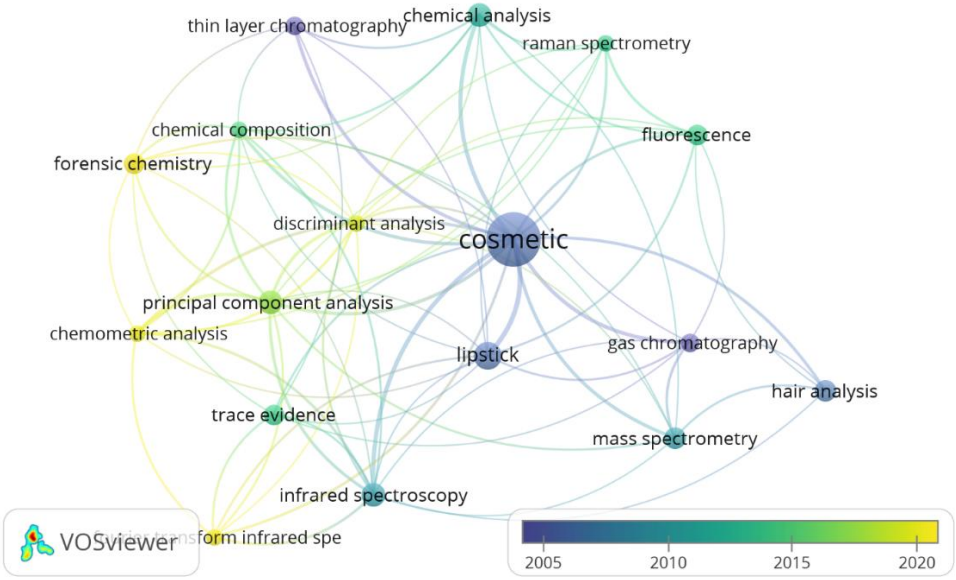

Chart 7: Graph showing the mapping of co-occurred keywords along with timeline

A manual count of the most utilized analytical technique and the most researched cosmetological product was conducted. It could be clearly inferred from chart 8 that the most used analytical technique for the analysis of cometic products were mass spectrometry and ATR-FTIR with occurrence of about 19% and 17% respectively. Similarly chart 9 comprehends that most researched cosmetic products were, lip cosmetics with occurrence of 38% followed by hair cosmetics with occurrence of 23%.

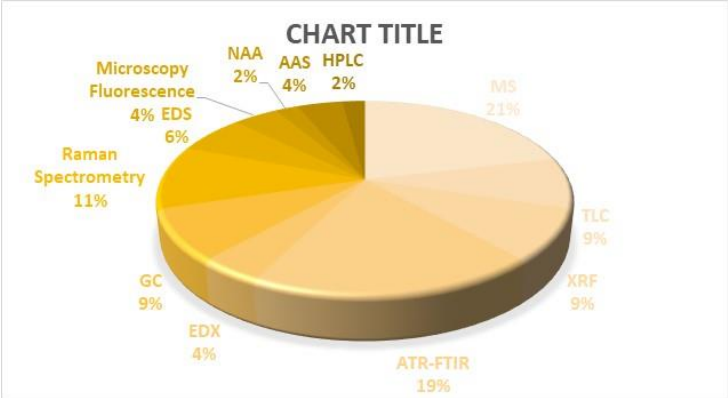

Chart 8: Occurrence of all analytical techniques used in the field

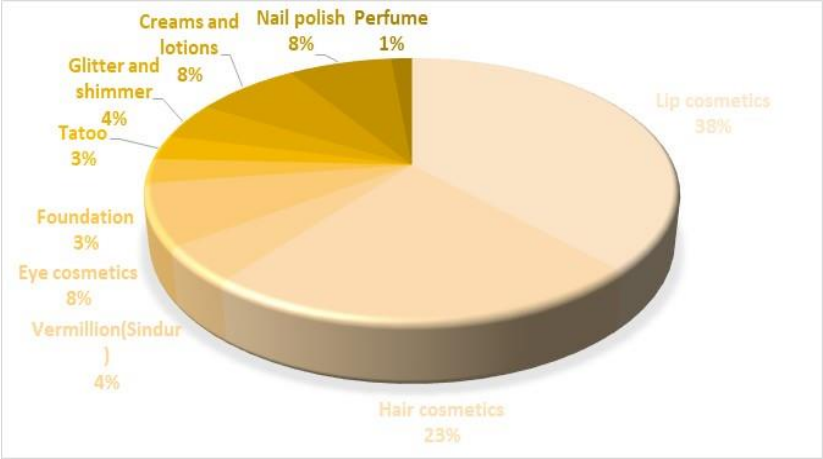

Chart 9: Occurrence of all cosmetic products used for research

Table 1: List of most cited references

S. No.	TITLE	AUTHOR	JOURNAL	CITATIONS
1	Differentiation of red lipsticks using the attenuated total reflection technique supported by two chemometric methods	gladysz m., krol m., koscielniak p.	Forensic Science International	7
2	Confocal Raman spectroscopy to trace lipstick with their smudges on different surfaces	lopez-lopez m., ozbek n., garcia-ruiz c.	Talanta	7
3	Differentiation of lipsticks by Raman spectroscopy	salahioglu f., went m.j.	Forensic Science International	7
4	Analysis of lipsticks using Raman spectroscopy	gardner p., bertino m.f., weimer r., hazelrigg e.	Forensic Science International	6
5	Analysis of lipsticks	russell l.w., welch a.e.	Forensic Science International	6
6	Identification of lipstick smears by fluorescence observation and purge-and-trap gas chromatography	Ehara Y.; Marumo Y.	Forensic Science International	5
7	Forensic discrimination of lipsticks using visible and attenuated total reflectance infrared spectroscopy	wong j.x.w., sauzier g., lewis s.w.	Forensic Science International	5

Table 2: Listed of cited journals

S.No.	Journal	TP	TC	CPP	Cite Score	SNIP	SJR	H-index
1	Forensic Science International	16	495	30.93	4.8	1.18	0.74 Q1	134
2	Cleveland clinic journal of medicine	1	17	17	3.3	0.711	0.496 Q3	107
3	Forensic Chemistry	1	25	25	4.5	1.131	0.831 Q1	145
4	International journal of medical toxicology and legal medicine	1	0	0	0.7	0.356	0.224 Q3	169
5	Journal of Applied Spectroscopy	1	22	22	1.3	0.423	0.423 Q4	178
6	Journal of Chemical Education	1	2	2	5.2	1.05	0.555 Q2	50
7	Journal of Chromatography A	1	18	18	7.4	1.02	0.766 Q1	23
8	Journal of Forensic and Legal Medicine	1	8	8	3.1	1.119	0.516 Q1	99
9	Journal of forensic identification	3	19	6.33	0.3	0.144	0.174 Q4	29
10	Journal of forensic sciences	8	144	18	3.4	0.931	0.607 Q2	85
11	Journal of Punjab academy of forensic medicine and toxicology	1	0	0	0.1	0.095	0.126 Q4	31
12	Journal of the brazilian chemical society	1	17	17	3.8	0.538	0.316 Q3	244
13	Journal of the forensic science society	2	41	20.5	3.6	0.956	0.673 Q2	69
14	Materials today: proceedings	4	0	0	3.2	0.774	0.445 Q2	76
15	Microchemical journal	4	23	5.75	8.6	1.068	0.733 Q1	62
16	Romanian journal of legal medicine	1	1	1	0.5	0.098	0.141 Q4	54
17	Science and Justice - Journal of the Forensic Science Society	1	6	6	3.6	0.956	0.673 Q2	86
18	Spectrochimica acta - part a: molecular and biomolecular spectroscopy	2	64	32	7.9	1.037	0.635 Q2	50
19	Talanta	2	47	23.5	12.2	1.168	0.986 Q1	50
20	Toxicologie analytique et clinique	1	0	0	1.2	0.314	0.212 Q4	79
21	Vibrational spectroscopy	1	7	7	4.3	0.839	0.373 Q3	95
22	X-ray spectrometry	1	7	7	3.0	0.662	0.281 Q4	15
23	ACS omega	1	1	1	5.9	0.941	0.694 Q1	77
24	Analyst	1	54	54	8.3	0.886	0.789 Q1	11
25	Analytical methods	2	20	10	5.5	0.678	0.535 Q2	11
26	Analytical sciences	1	4	4	2.9	0.464	0.273 Q3	8
27	Anil Aggarwal's internet journal of forensic medicine and toxicology	1	1	1	0.2	0.017	0.103 Q4	69
28	Drug testing and analysis	2	17	8.5	5.7	1.034	0.704 Q1	11

TP= total publications; TC=Total Citations; CPP=citations per publications; SNIP=Source normalized impact per paper; SJR=Scimago Journal Ranking; (SCOPUS data for year 2022)

4. Author analysis

The parameter selected for finding the most co-cited author was created by including authors who have been cited 20 times. The mapping obtained henceforth is shown in chart 10. It could be inferred that, Rajinder Singh with 17.13% and Vishal Sharma with 13.94% citations were the most cited authors of the field. The table 3 mentioned below provides further details of the major contributors of the field. Table 1 provides list of most cited publications along with its authors, journal and citations. In addition, a list of all the journals of the field and related parameters are mentioned in table 2.

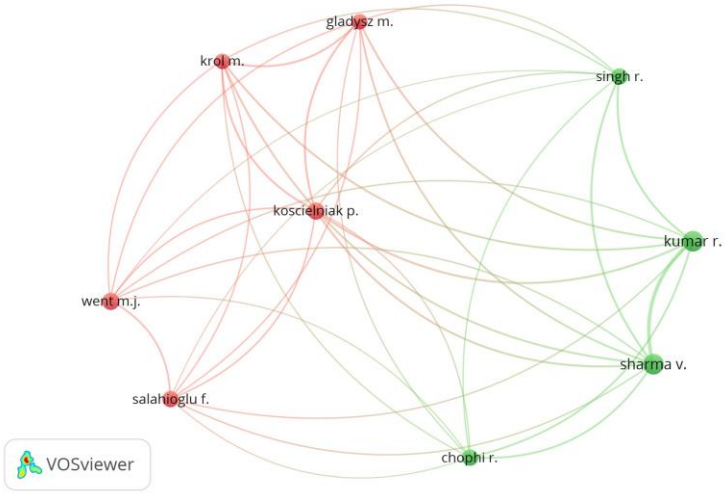

Chart 10: Co- cited authors (at least cited 20 times)

5. Conclusion

In forensic investigations, cosmetics are essential because they provide important details that aid in the identification of victims and the reconstruction of crime scenes. Analyzing trace evidence is important because makeup, including lipstick, foundation, and eyeshadow, can leave unique traces that can identify victims or suspects. Furthermore, researching cosmetics might provide details about a person's habits, way of life, and socioeconomic standing. Certain brands or uncommon products, for example, may reveal information about a person's social circles or tastes. The transmission of cosmetic elements during physical contact can aid in the establishment of linkages between people and locales in cases involving violent crimes or attacks. Additionally, cosmetics can play a significant role in facial recognition technology, improving matching accuracy. In general, cosmetics are significant to forensics because they can reveal important information that advances our understanding of the events and helps law enforcement prosecute cases.

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7. Conflict of interest

The authors assert that they do not have competing interests.

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