



Scientometric Evaluation of Research on Bioceramics†

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During the past several years, there has been a major advance in the development of biomedical materials including various ceramic materials for skeletal repair and reconstruction. To understand bioceramics research trends, we investigated total 12,157 research papers published from 2003 to 2012. These research papers were published by 100 countries. The bioceramics research had steadily increased each year. The bioceramics research trends had expanded from hydroxyapatite to hydroxyapatite, calcium phosphate and titania for the last 10 years.

Keywords: Bioceramics, Scientometric analysis, Research trend, Biocompatibility, Biodegradable materials.

INTRODUCTION

Obviously, different types of biomaterials are in use depending on the tissue to be replaced¹. If we focus on functional artificial biomaterials, the choice has to be made among metals, polymers and bioceramics. Bioceramics are the most and can be obtained with biostable, bioactive or bioresorbable properties²⁻⁴. The development of bioceramic materials is at the forefront of health-related issues in many countries⁵. For instance, the development of new mesoporous nanoceramics, suitable to be used as carriers for drug delivery⁶, has also opened new perspectives for cancer therapies⁷. Research into bioceramics has reached a level of involvement and sophistication and application of bioceramics has been made widely and diversely in medicine. Therefore, it's really important to understand development trends in this area in order to pre-study for the research plan. In this study, bioceramics research trends were reviewed using 12,157 research papers published from 2003 to 2012.

EXPERIMENTAL

A search was carried out in the Science Citation Index (SCI) using "web of knowledge" database of the Thomson Reuters. Table-1 shows search query for papers on bioceramics from 2003 to 2012. The scientometric analysis of papers was performed using the COMPAS (COMPetitive Analysis Service), KM (Knowledge Matrix), Gephi, NetMiner and VOSviewer.

TABLE-1
SEARCH QUERY FOR PAPERS ON BIO CERAMICS

No.	Search Query
1	Topic=(hydroxyapatite OR silicate OR bioceramic OR bioglass OR titania OR alumina OR apatite OR zirconia OR "calcium phosphate" OR "Tri-calcium phosphate") Databases=SCI-EXPANDED Timespan=2003-2012
2	Topic=(stem*OR bone* OR hip* OR knee* OR implant* OR scaffold*) Databases=SCI-EXPANDED Timespan=2003-2012
3	#2 AND #1 Databases=SCI-EXPANDED Timespan=2003-2012

COMPAS and KM were developed by KISTI (Korea Institute of Science and Technology Information)⁸.

RESULTS AND DISCUSSION

About 12,157 research papers on bioceramics were published from 2003 to 2012. Fig. 1 shows the distribution of papers by year. We found that the bioceramics research has steadily increased every year, since 771 papers were published only in 2003.

About 12,157 research papers on bioceramics were published by 100 countries. Fig. 2 shows the number of papers published by major 10 countries in this field. USA published 2,344 papers and followed China (1,868), Japan (1,405), Germany (1,110), UK (1,037), France (816), South Korea (692), Italy (554), Spain (518) and Netherlands (382).

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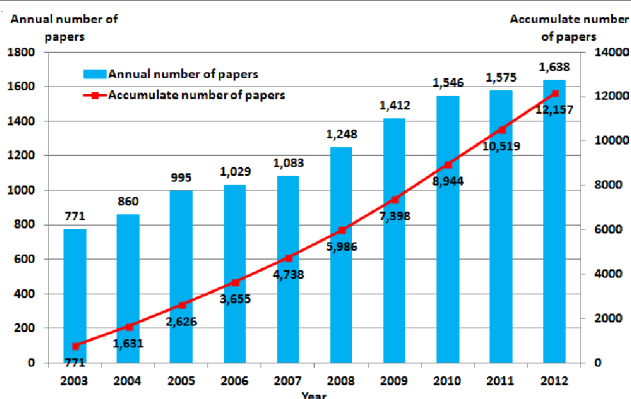


Fig. 1. Number of papers on bioceramics published from 2003 to 2012

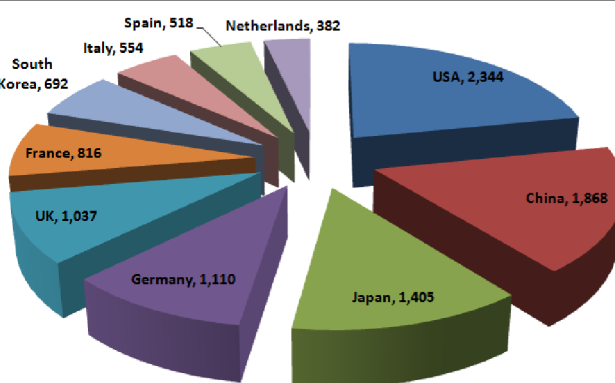


Fig. 2. Number of papers on bioceramics published by major 10 countries

In order to investigate the co-work network-map of the inter country on the bioceramics research, we analyzed the nationality of authors on 12,157 research papers as shown in Fig. 3. It shows that USA mainly co-worked with China, Japan, Germany, UK, France, Italy and South Korea. China mainly

co-worked with USA and Japan. Japan mainly co-worked with USA and China. Germany mainly co-worked with USA, UK and Switzerland. South Korea mainly co-worked with USA.

Fig. 4 shows the network-map of countries and technologies about 12,157 papers on bioceramics. It shows that major

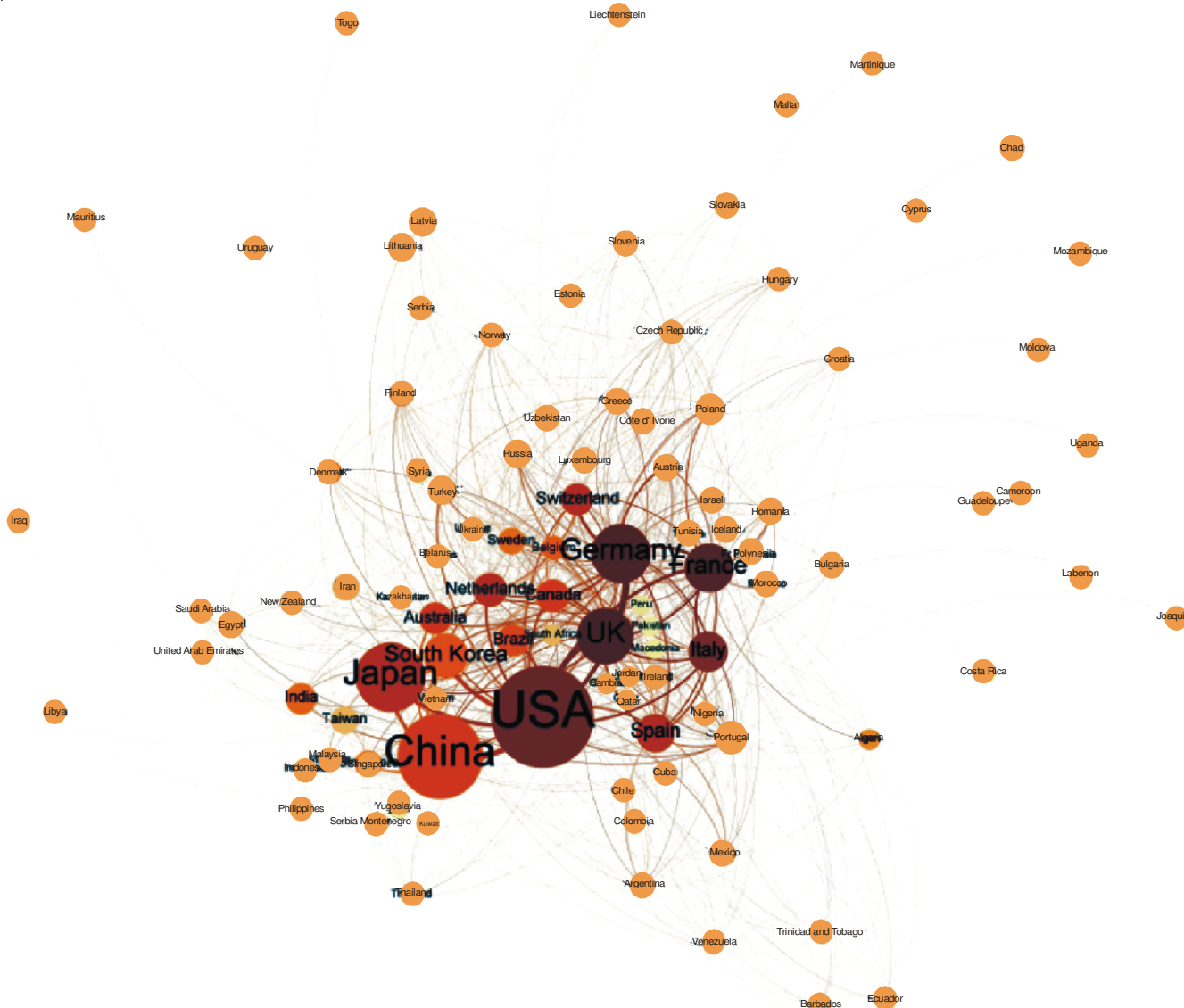


Fig. 3. Co-work network-map of the inter country on the bioceramics research

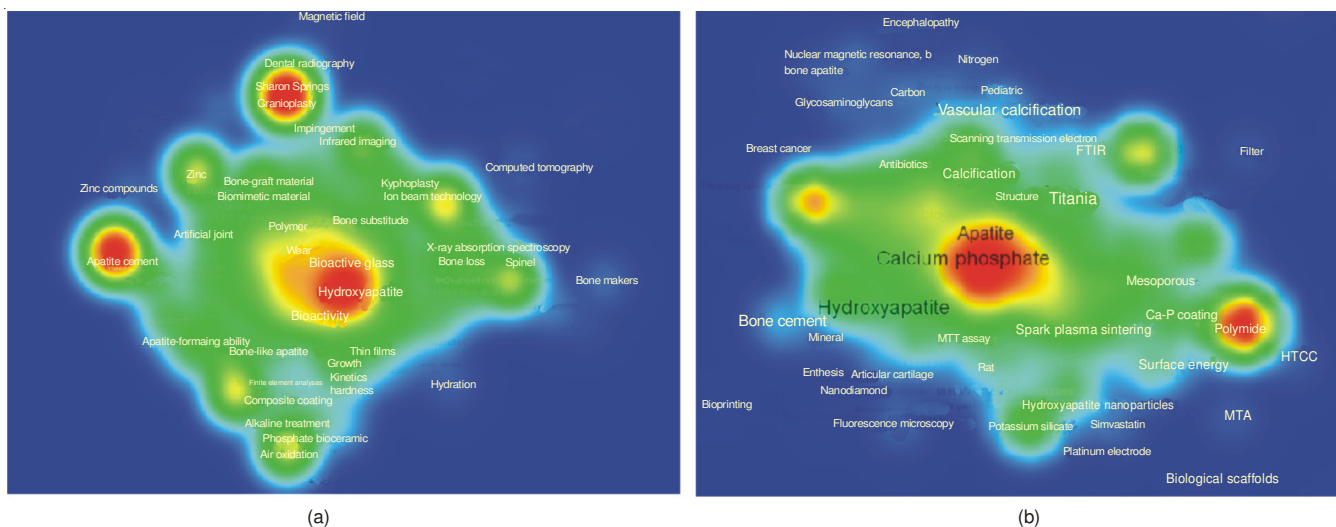


Fig. 5. Main topics on bioceramics research 2003-2004(A) and 2011-2012(B), respectively

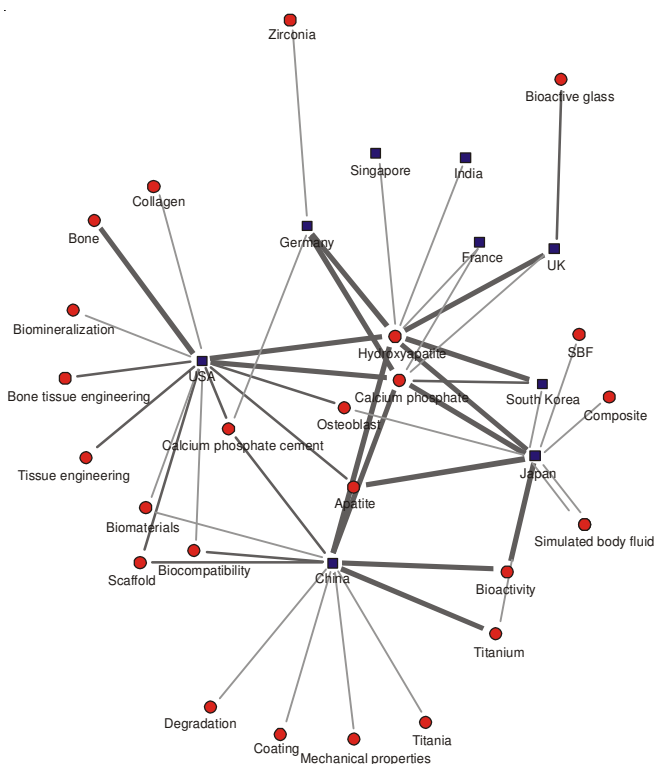


Fig. 4. Network-map of countries and technologies about 12,157 papers on bioceramics. The node ■ is a country. The node ● is a technology. The thinnest link means 50 frequencies and the thickness of link is proportional to the frequency

10 countries (USA, China, Japan, Germany, UK, France and South Korea) and core technologies. In hydroxyapatite field, USA, China, Japan, Germany, UK and South Korea are major countries. In calcium phosphate field, USA, China, Japan and Germany are major countries. In bioactivity field, China and Japan are major countries. In bone and bioactive glass field, USA and UK are respectively major countries.

In order to investigate the changing trend of main topics on bioceramics research, we analyzed main topics in the years 2003-2004 and 2011-2012, respectively as shown in Fig. 5. It shows that the main topic was hydroxyapatite in 2003-2004,

while main topics were hydroxyapatite, calcium phosphate and titania in 2011-2012. In other words, the bioceramics research trend had expanded from hydroxyapatite to hydroxyapatite, calcium phosphate and titania for the last 10 years.

Conclusion

In this study, the method of scientometric analysis was used to investigate bioceramics research trends. 12,157 papers were published by 100 countries from 2003 to 2012. The bioceramics research has steadily increased every year, since 771 papers were published in 2003. Major 10 countries were USA (2,344 papers), China (1,868 papers), Japan (1,405 papers), Germany (1,110 papers), UK (1,037 papers), France (816 papers), South Korea (692 papers), Italy (554 papers), Spain (518 papers) and Netherlands (382 papers). USA mainly co-worked with China, Japan, Germany, UK, France, Italy and South Korea. China mainly co-worked with USA and Japan. Japan mainly co-worked with USA and China. Germany mainly co-worked with USA, UK and Switzerland. South Korea mainly co-worked with USA. In hydroxyapatite field, USA, China, Japan, Germany, UK and South Korea are major countries. In calcium phosphate field, USA, China, Japan and Germany are major countries. In bioactivity field, China and Japan are major countries. In bone and bioactive glass field, USA and UK are respectively major countries. The bioceramics research trend had expanded from hydroxyapatite to hydroxyapatite, calcium phosphate and titania for the last 10 years.

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