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Competitiveness Analysis of Institutes on Biomedical Magnesium Alloys†

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Recently, the interest in biomedical magnesium alloys has been increased. In this paper, to understand biomedical magnesium alloys research and development trends, we investigated total 590 research papers published from 2001 to 2012. These papers were published by 437 institutes of 39 countries. The biomedical magnesium alloys study had significantly increased since the late 2000's. Hannover Med. Sch.(4.4) and Monash Univ.(3.2) had the highest Q_1 (index level of paper quality) and Q_2 (strength of international collaboration) value, respectively. Main research topics were biodegradation, biocompatibility, biomaterials, biodegradable materials, biodegradable stents, bioactivity, bio-corrosion and *in vitro*.

Keywords: Magnesium alloys, Biomaterials, Scientometric analysis, R&D trend, Biodegradable materials, Biocompatibility.

INTRODUCTION

The development of biodegradable implants is one of the important areas in medicine[1-3]. Compared with a traditional permanent implant, a biodegradable material is not cause permanent physical irritation or chronic inflammatory discomfort. Currently, the biodegradable implants are mainly made of polymers[2]. However, these polymer based implants usually have an unsatisfactory mechanical strength[3].

Magnesium is light metal with characteristics of low density, high specific strength and high specific stiffness[4]. In particular, the elastic modulus and compressive yield strength of magnesium are close to the natural bone. Magnesium is an essential element which is a part of the bone structure. Dissolved magnesium ions may promote bone cell attachment, tissue growth at the implants[5]. The results of studies in many clinical cases, *in vitro* and *in vivo* have demonstrated that magnesium alloys possess good biocompatibility[6]. These characteristics of magnesium make them a promising substitute for biodegradable implant applications in the biomedical field[7]. Recently, a range of applications of magnesium alloys has been made widely and diversely in the biomedicine. Therefore, it's really important to understand development trends in this area in order to pre-study for the research plan. In this study, biomedical magnesium alloys research and development trends were reviewed using 590 research papers published from 2001 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 biomedical magnesium alloys from 2001 to 2012. The scientomatric analysis was performed using the COMPAS (COMPetitive Analysis Service), KM (Knowledge Matrix), NetMiner and VOSviewer. COMPAS and KM were developed by KISTI (Korea Institute of Science and Technology Information)[8].

RESULTS AND DISCUSSION

About 590 research papers on biomedical magnesium alloys were published from 2001 to 2012. Fig. 1 shows the distribution of papers per year. We found that the biomedical magnesium alloys study has significantly increased since the late 2000's.

About 590 research papers on biomedical magnesium alloys were published by 437 institutes. Fig. 2 shows the yearly number of papers published by major 10 institutes. Chinese Acad. Sci. published 58 papers and followed Shanghai Jiao Tong University (41), Hannover Med. Sch. (31), Harbin Inst. Technol. (29), Leibniz University Hannover(27), City University Hong Kong (26), Peking University (22), Zhengzhou University (18), Monash University (17) and GKSS Forschungszentrum Geesthacht GmbH (16).

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TABLE-1
SEARCH QUERY FOR PAPERS ON BIOMEDICAL MAGNESIUM ALLOYS

No.	Search Query
1	Title = (magnesium) OR Title = (Mg*) Databases = SCI-EXPANDED Timespan = 2001-2012
2	Title=(alloy*) Databases=SCI-EXPANDED Timespan = 2001-2012
3	Topic=("magnesium alloy" or "magnesium alloys" or "Mg alloys" or "mg alloy") Databases=SCI-EXPANDED Timespan=2001-2012
4	#2 AND #1 Databases=SCI-EXPANDED Timespan=2001-2012
5	#4 OR #3 Databases=SCI-EXPANDED Timespan=2001-2012
6	Topic=(bone* or biocompat* or implant* or biodegrad* or biomed* or human* or biomaterial* or coronary or orthoped* or biometal*) OR Title=(bio*) Databases=SCI-EXPANDED Timespan=2001-2012
7	#6 AND #5 Databases=SCI-EXPANDED Timespan=2001-2012

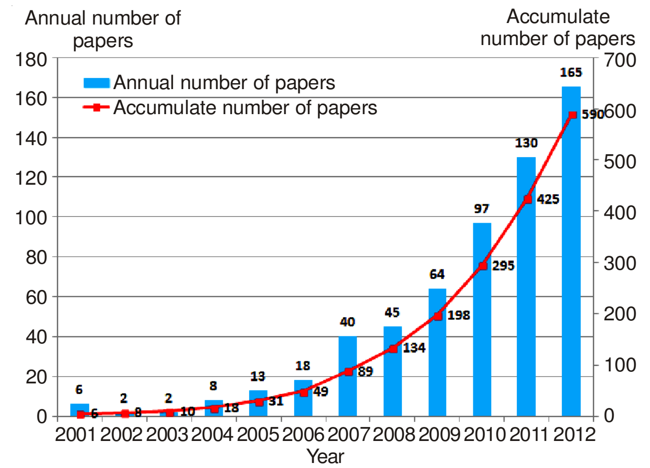

Fig. 1. Number of research papers on biomedical magnesium alloys published from 2001 to 2012

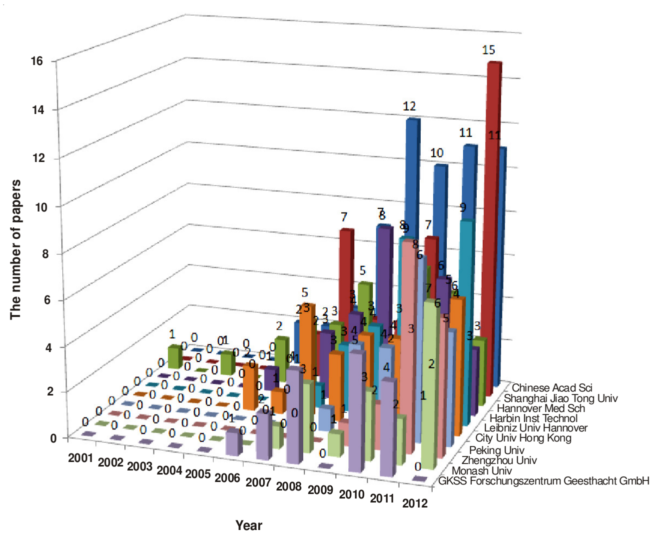

Fig. 2. Number of research papers on biomedical magnesium alloys published by major 10 institutes

Fig. 3 shows Q_1 (index level of paper quality) and Q_2 (strength of international collaboration) of major institutes in biomedical magnesium alloys. Equations of Q_1 and Q_2 are as follows, respectively.

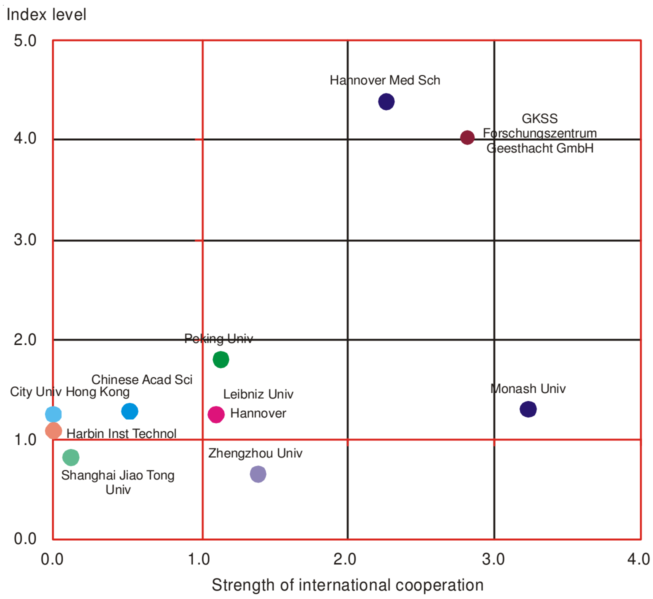

Fig. 3. Q_1-Q_2 distribution of major institutes in biomedical magnesium alloys research (Q_1: index level of paper quality, Q_2: strength of international collaboration)

$$Q_1 = \frac{N_1}{M_1} \quad (1)$$

$$Q_2 = \frac{N_2}{M_2} \quad (2)$$

M_1 is the average cited number of research papers in a certain technical area, in this case it means biomedical magnesium alloys; N_1 is the average cited number of papers published by a certain institute. Hannover Med. Sch. (4.4) has the highest Q_1 value, followed by GKSS Forschungszentrum Geesthacht GmbH (4.0), Peking University (1.8), Monash University (1.3) and Chinese Acad. Sci. (1.3).

M_2 is the average proportion of international collaboration per an institute in a certain technical area, in this case it means biomedical magnesium alloys; N_2 is the proportion of international collaboration of a certain institute. Monash University (3.2) has the highest Q_2 value, followed by GKSS Forschungszentrum Geesthacht GmbH (2.8), Hannover Med. Sch. (2.3), Zhengzhou University (1.4) and Peking University (1.1).

Fig. 4 shows the network-map of institutes and technologies 590 research papers on biomedical magnesium alloys. It shows that major 10 institutes and core technologies. In magnesium alloy field, Shanghai Jiao Tong University, Chinese Acad. Sci., Peking University and Zhengzhou University are major institutes. In *in vivo* corrosion field, Chinese Acad. Sci. and Peking University are major institutes. In bone field, Shanghai Jiao Tong University and Peking University are major institutes.

In order to investigate main topics on biomedical magnesium alloys study, 185 core technologies were selected from 1,257 keywords of 590 papers. 185 core technologies were grouped in a similar technology as shown in Fig. 5. It shows that main topics are biodegradation, biocompatibility, biomaterials, biodegradable materials, biodegradable stents, bioactivity, bio-corrosion and *in vitro*.

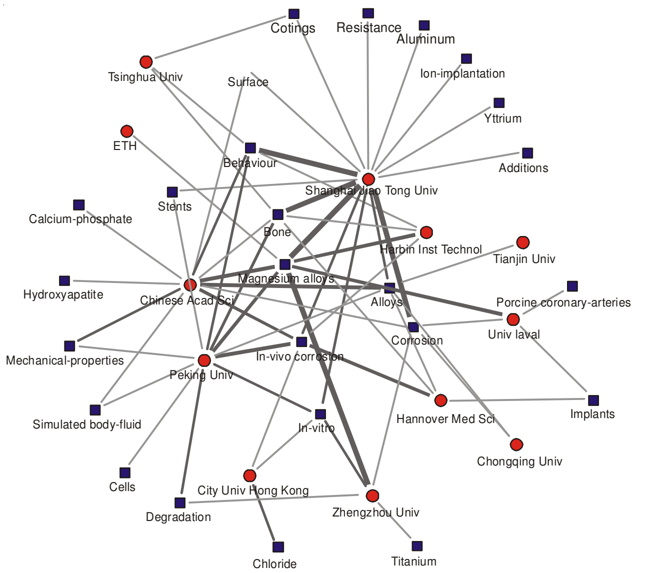

Fig. 4. Network-map of institutes and technologies 590 research papers on biomedical magnesium alloys. The node ● is an institute. The node ■ is a technology. The thinnest link means 5 frequencies and the thickness of link is proportional to the frequency

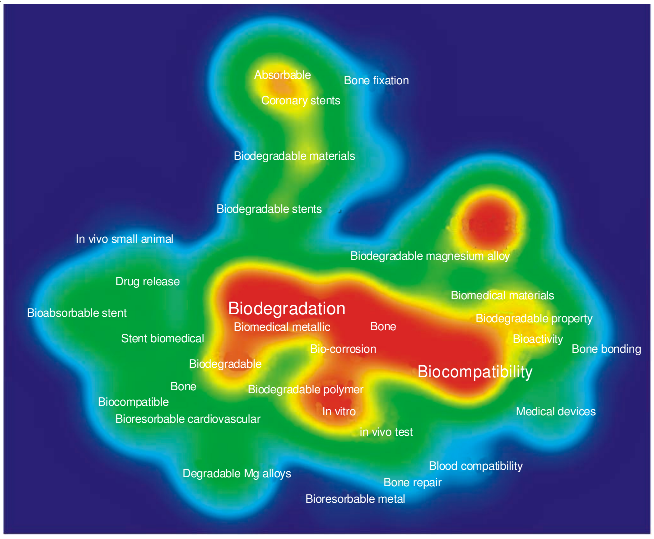

Fig. 5. Main topics on biomedical magnesium alloys research from 2001 to 2012

Conclusion

In this study, the method of scientometric analysis was used to investigate biomedical magnesium alloys research and development trends. 590 research papers were published by 437 institutes of 39 countries from 2001 to 2012. The biomedical magnesium alloys study had significantly increased since the late 2000's. Major 10 institutes were Chinese Acad. Sci. (58 papers), Shanghai Jiao Tong University (41 papers), Hannover Med. Sch. (31 papers), Harbin Inst. Technol. (29 papers), Leibniz University Hannover (27 papers), City University Hong Kong (26 papers), Peking University (22 papers), Zhengzhou University (18 papers), Monash University (17 papers) and GKSS Forschungszentrum Geesthacht GmbH (16 papers). Hannover Med. Sch. (4.4) and Monash University (3.2) had the highest Q_1 and Q_2 value, respectively. In magnesium alloy field, Shanghai Jiao Tong University, Chinese Acad. Sci., Peking University and Zhengzhou University are major institutes. In *in vivo* corrosion field, Chinese Acad. Sci. and Peking University are major institutes. In bone field, Shanghai Jiao Tong University and Peking University are major institutes. Main research topics were biodegradation, biocompatibility, biomaterials, biodegradable materials, biodegradable stents, bioactivity, bio-corrosion and *in vitro*.

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