"Recent Progress of the Science of Biomedical Polymeric Materials"

Prof. K. Takemoto

Comment (*Prof. M. Miyata*) :
Professor Takemoto talked about biomaterials made of synthetic polymers with mechanical strength. My comment is concerned with biomaterials made of assemblies of organic molecules. The designing of such materials is based on an important concept in current chemistry, called "inclusion phenomena". The term is applied to phenomena that some organic molecules (called hosts) include another molecules (called guests) into their cavities.
The well-know hosts are macrocyclic compounds such as cyclodextrin and crown ether. For example, prostaglandin, a valuable but unstable pharmaceutical, can be included into a central cavity of a cyclodextrin molecule. The inclusion leads a stabilization of the pharmaceutical. Another representative hosts are functional biopolymers such as enzymes. They can include specified guest molecules into their clefts to undergo highly selective reactions. The more interesting thing is that even the biopolymers are assemblies consisted of many different parts.
Thus, organic molecules form assemblies of small molecules. In other words, the assemblies are typical composite materials at molecular level. The designing of biomaterials should need a concideration from a viewpoint of molecular composites.

Question (*Dr. C.C. Berndt*) :
Please comment on the usage of • composites, eg HAp + HDPE for plates etc. and • cements (for orthopsedic applications) in Japan.

Answer (*Dr. Takemoto*) :
Polymeric alloy has recently received much attention. A number of researchers, particularly in industries is now pushing forward their studies for constructing such composites, not only between two sorts of polymers, but also between a polymer and another material such as metal or ceramic fibers. To produce specific composite materials in such ways seems to be very interesting and important.

"Hydroxyapatite of Great Promise for Biomaterials"

Prof. H. Aoki

Comment (*Dr. T. Nakamura*) :
The biocompatibility is a most important problem on applying artificial materials to biomaterials. Since the usage of hydroxyapatite as single materials is often limited as biomaterials, the hybrid materials of hydroxyapatite with other materials are recommended as biomaterials.
Did you prepare the composite materials of hydroxyapatite with other materials as biomaterials?

Answer (*Porf. H. Aoki*) :
We have already tried to prepare the composite materials of hydroxyapatite with other materials as biomaterials. First, we have prepared the alloys such as titanium and stainless steel coated by hydroxyapatite, which we have prepared using a thermal spraying techniuqe, and we have obtained the good biocompatibility of the coated materials.
Second, we are also making the composite materials of hydroxyapatite with polymers.

Concluding Remarks

Prof. M. Naka

In recent years, the research fields of Welding Research Institute of Osaka University have to change from the chagne in the research trend of the general other fields. Our Institue is required to expand the research works to the new fields such as life science & technology, nuclear and fusion power plant science & technology, space and aircraft science & technology, and electronics and information science and technology and so on as shown in **Fig. 1**. When the research field in our Welding Research Institute overlaped with other new reserch fields in **Fig. 2**, the new possibility of research works will take place at the interface scienes. One possibitity of research works is the topic of biomaterials in **Fig. 3** that is presented in the SIMAP '88 symposium.
In the biomaterials session of this International Symposium of SIMAP '88, the two key notes were presented by Prof. Takemoto, Osaka University and Prof. Aoki, Tokyo Medical and Dental University, and the two discussions by Dr. Miyata, Osaka University and Dr. Nakamura, Kyoto University, respectively.
As discussed by Profs. Takemoto and Aoki, the artificial biomaterials require a variety of difficult properties such as biocompatibility, chemical stability and mechanical strength as shown in **Fig. 4**. In particular, the biocom-

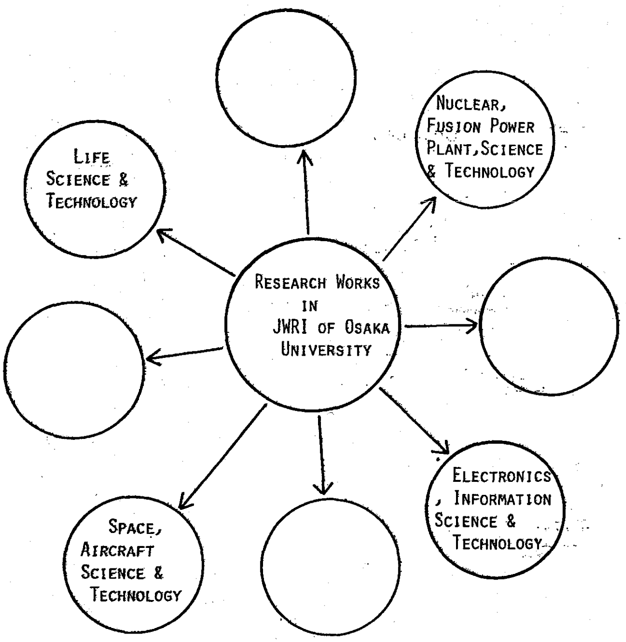

Fig. 1 Expansion of research fields for Welding Research Institute of Osaka University.

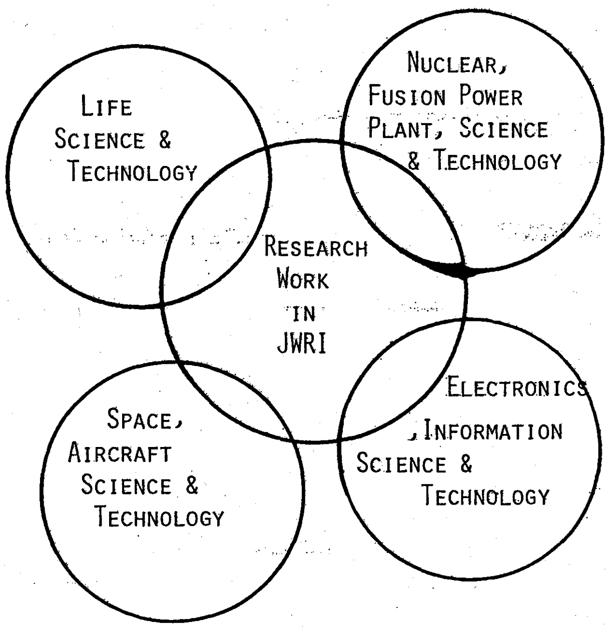

Fig. 2 New posibilities at interface sciencse.

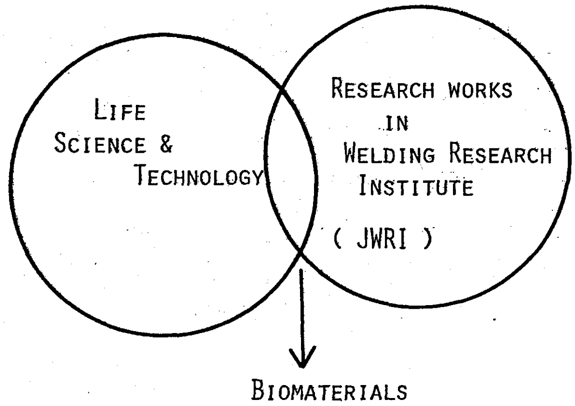

Fig. 3 Biomaterials as topic at the overlaping filed between life science and technology, and research works in Welding Research Institute, Osaka University.

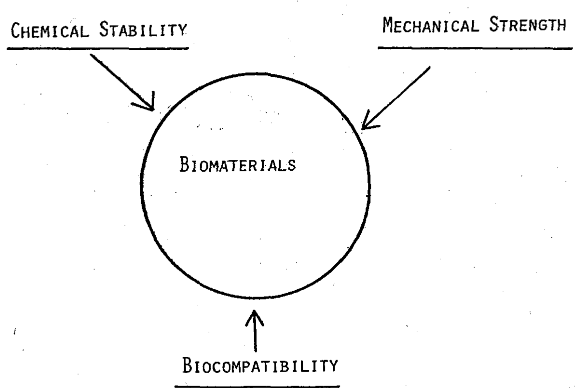

Fig. 4 A variety of properties of biomaterials necessiated.

patibility against human bodies is the quite severe property, compared with other properties required in the usual material engineering.

The biomaterials, in general, are classified into biometals, bioceramics and biopolymers. The topics of biometals are not discussed from the limited talking time in the symposium.

A variety of artificial polymers such as methacrylic resin cupropane and cardiothane and so on are used as the artificial biomaterials as presented in **Table 1**[1]. The typical one is the cardiothane for the artificial heart.

The recent interests are forcused on the hydroxyapatite among the bioceramics. The hydroxyapatie, $Ca_{10}(PO_4)_6(OH)_2$, possesses the good biocompatibiity and mechanical properties[2]. **Table 2** gives the medical and dental application of hydroxyapatie[2].

From the development of biomaterials fields we can learn how the advanced materials are developed as shown in **Fig. 5**, and may apply the advancing processes such as hybridization, composition, modification, synthesis and preparation of new functional materials into the research fields of our Welding Research Institute.

Table 1 Application of biopolymers.

BIOMATERIALS	MATERILAS
CONTACT LENSES	METHACRYLIC RESIN ACRYLIC HYDROGELS (OXYGEN PERMEATION + OPTICAL TRANSPARENT)
DENTAL POLYMER	METHACRYLIC POLYMER
ADSORBABLE SUTURES	POLYGLYCOLIC ACID
ARTIFICAL SKIN	BILAYER POLYMERIC MEMBRANCE
ARTIFICAL KIDNEY	CUPROPANE
ARTIFICAL LUNG	POROUS POLYPROPYLENE
ARTIFICAL HEART	SYNTHETIC POLYMER, CARDIOTHANE

Finally we conlude the discussion of biomaterials as follows;

1. The Welding Research Institute of Osaka University (JWRI) have to play in developing a varitey of sciences and technologies in the new future. For instance; life science and technology, nuclear and fusion power plant science and technology, space and aircraft science and technology, and electronics and information science and technology and so on.
2. New possibilities of research works will take place at the interface between JWRI and other fields such as life science and technology; the fields of biomaterials.
3. Biomaterials are divided into
   (1) Biomedical polymeric materials (new polymers).
   (2) Biomedical ceramics such as hydroxyapatite.
   (3) Biomedical metals.
4. Biomaterials are produced by a variety of processes such as hybrization, composition and synthesis of new materials.

1) K. Takemoto : Proc. SIMAP'88, Osaka, 1988, P.91
2) H. Aoki : Proc. SIMAP'88, Osaka, 1988, P.99

Table 2 Application of hydroxyapatite for medical and dental use.

Medical Use	Dental Use
Artificial bone	Dentifries
Artificial joint	Cement
Bone filler	Canal
Artificial blood vassel	Bone filler
Artificial tracheal	Tooth root
Percutaneous device	Porous bone
	Porcelain tooth

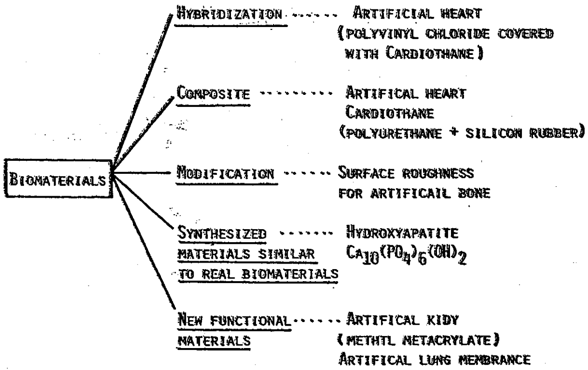

Fig. 5 Advancing processes of biomaterials.