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Magnetic rotations of uric acid crystals and uratic crystals by static magnetic fields of up to 500 mT

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Abstract— **In recent years, the disease concerning ureteral calculus is increasing possibly due to the changing lifestyles. For example, it is well known that the urinary calculi have a large impact to gout. As eating habitual diseases, gout and the hyper-uricemia are related to the formation of urinary calculus. In the previous studies, therapeutic agents were developed to enhance the uric acid excretion. From the viewpoint of side effects induction by the chemical agents, we are motivated to explore an alternative method to control the formation of ureteral crystals stimulator by physical stimulations. Therefore in the present study, we focused on the behaviors of uric acid crystals under magnetic fields of several hundreds of mT (Tesla). The uric acid crystals were re-crystallized from a suspension of uric acid powder, and the micro-crystals were prepared to be floating in the solution. We generated horizontal magnetic fields of maximum 500 mT by an electromagnet which contained a CCD microscope. A permanent magnet with magnetic fields of 200~400 mT was also utilized. During the magnetic fields were applied to the uric acid crystals, we observed that the uric acid crystals were oriented by the magnetic fields down to 200 mT at the room temperature. It was speculated that the dimagnetic anisotropy in the uric acid crystals exhibited the rotational responses. The results indicate the possible remote control of the uric acid crystals in living body by the magnetic fields of 200 mT to 500 mT**.

I. Introduction

In recent years it is well known that there is possibility that one of seven men is ailing urinary tract stone disease [1]. Usually the urine is produced by the kidneys through the ureters. And it is discharged to extracorporeal through the urethra into the bladder accumulate (Fig.1). This course is called a urinary tract. The urinary calculus is a disease to have calculi on this urinary tract. The urinary tract calculi are classified into upper urethra lithiasis and the lower urethra lithiasis which is a calculus in a bladder and the urethra. 95% of people having a urinary tract calculus are ailing upper urethra lithiasis.

The urinary tract calculi are classified in ingredients such as calcium oxalate, calcium phosphate, uric acid and cystine. We focused on the uric acid crystals. It is known as a material that is causing the gout. And it is well known that the urinary calculi have a large impact to gout [2-5]. As eating habitual diseases, gout and the hyper-uricemia are related to the formation of urinary calculus [6-9]. It has been developed a therapeutic agent which can be used for uric acid excretion stimulator. For the purpose of improving the quality of life, another approach to control the uric acid crystal formation shold ve developed. In the present study, we focused on the magnetic field effects on the characteristics of the uric acid which was a causative agent of the gout. We started a basic study of the magnetic treatment in gout and the urinary tract calculus.

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II. Methods

A. sample preparation

The uric acid powder (98 % of purity, 7.5 mg) was dissolved completely in 2 ml aqueous solution of sodium hydroxide; 2 ml hydrochloric acid was added to generate a precipitate of uric acid crystals in the bottom of incubation tube.

The obtained crystals were transferred to a micro chamber which was consisted of a cover glass window. The thin chamber was set in a CCD microscope which was set in an electromagnet, as shown in Fig. 2. We observed the dynamic motion of uric acid crystals and uratic acid crystals by adding a solvent fluctuation by means of pipetting with 3 ml of pipet (Falcon 3557).

The image of crystals was recorded on a MPEG-2 recorder, and the obtained static images were analyzed on a capture analyzing software, Image-J. Parameters such as the angular velocity of crystals, and so on were calculated.

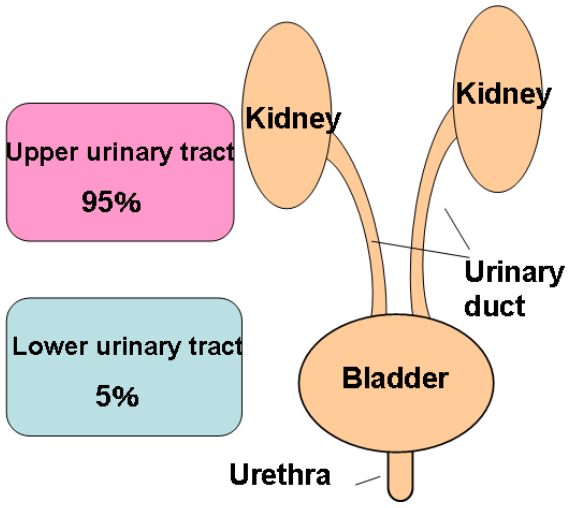

Figure 1. A model of urinay tract.

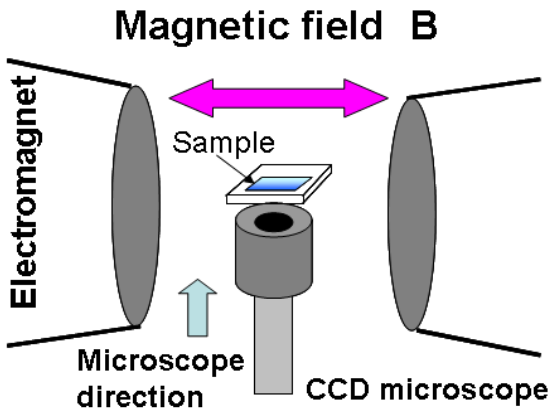

Figure 2. Experiment system for observing the effects of magnetic fields on the behaviors of uric acid crystals.

B. magnetic field generators

We observed the sample on a CCD microscope placed in the bore of the electromagnet to it. The magnet field strength of the electromagnet was set at 0 to 0.5 Tesla (500 mT). The electromagnet (resistive type, 50mm in diameter of magnetic poles, produced by Hayama Corp. Ltd., Fukushima, Japan) generated the maximum magnetic fields of up to 500 mT within 1 second.

III. RESULTS AND DISCUSSION

Figure 3 shows examples of re-crystallized uric acid crystals in a saturated suspension of uric acid powder. By adding hydrochloric acid, the shape and size of uric acid crystals changed. It was speculated that the rod-like shaped crystals had the structure of crystals (uratic crystal) usually observed in ureteral calculus while the "needle assembly" in right upper photo was of uric acid crystals usually generated in the diseased part (gout).

The crystal has been precipitated from the uric acid solution. And rod-shaped and needle-shaped crystals have been arranged at random. Figure 4 shows photos of uric acid crystals under magnetic fields of several hundreds of mT (Tesla). The crystal showed a tendency to orient perpendicular to the magnetic after the magnetic field on. It was oriented at 0.5 Tesla - 0.2 Tesla and was not oriented at 0.1 Tesla. As the magnetic field becomes small, the orientation speed was reduced. The crystal orientation was difficult to. Then stop the magnetic field is applied, it was returned to the environment magnetic field. But oriented crystal did not return to the original.angle

Figure 5 shows angular velocity when changing the magnetic field. The angular velocity is calculated from the rotation angle and the time needed to orient The crystal which were applied to the magnetic field were limited to an size of $2.8nm^2$-$3.4nm^2$. As a result, the angular velocity became large when we increased the magnetic field. The angular velocity gradually saturated. The result indicates that magnetic fields at 200~500mT was large enough for the orientation of uric acid crystals.

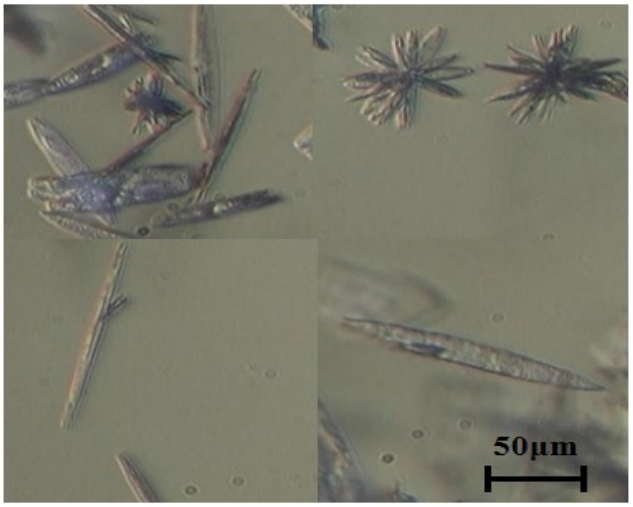

Figure 3. Examples of re-crystallized uric acid crystals in a saturated suspension of uric acid powder.

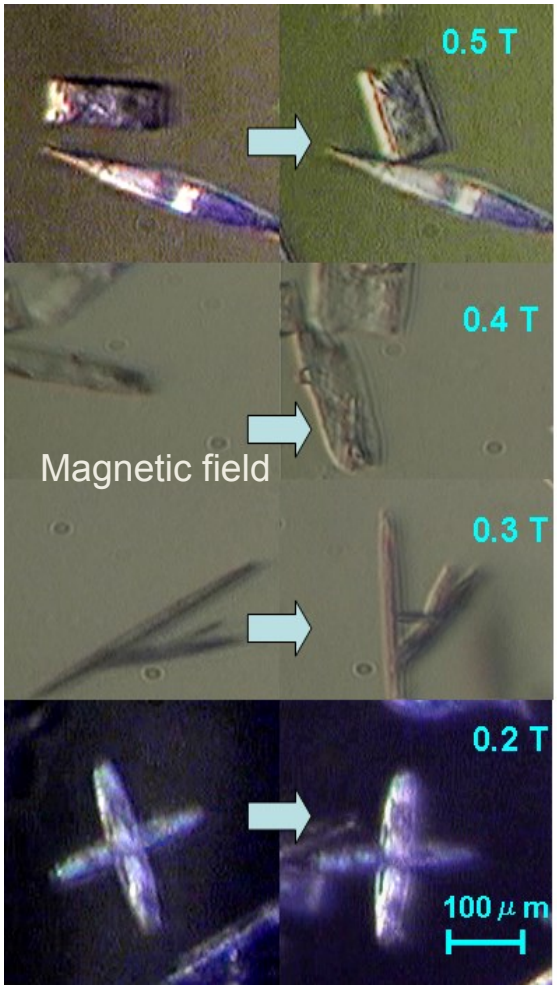

Figure 4. Magnetic rotation of uric acid crystals under magnetic fields of several hundreds of mT (Tesla).

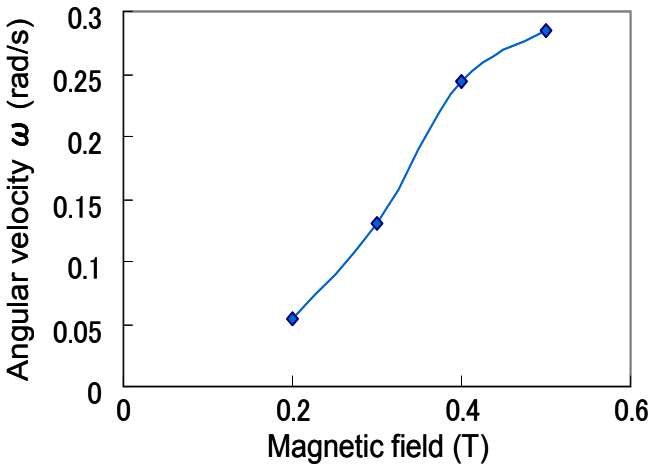

Figure 5. Angular velocity of the uric acid crystals dia-magnetically rotating around the applied magnetic fields of 200mT – 500mT.

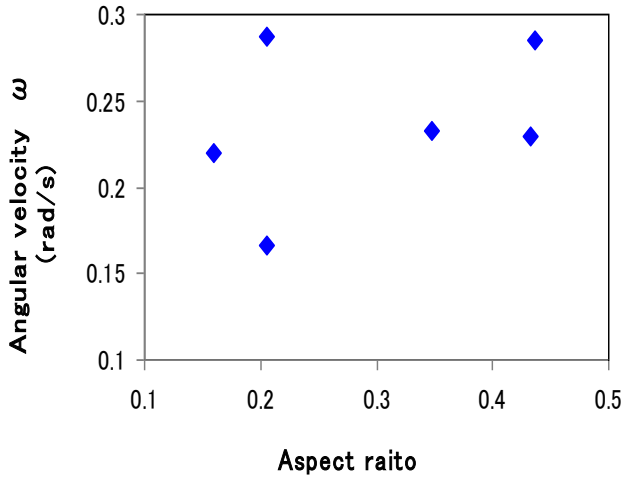

Figure 6. Dependence of angular velocity on the aspect ratio of the uric acid crystals dia-magnetically rotating around the applied magnetic fields.

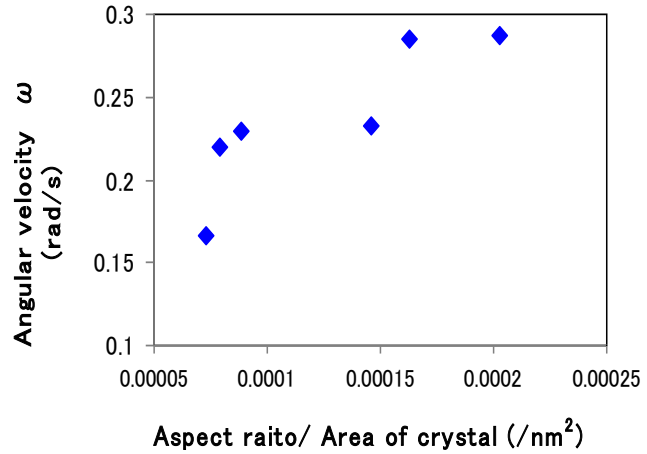

Figure 7. Dependence of angular velocity on the aspect ratio, which was divided by the area of each of uric acid crystals dia-magnetically rotating around the applied magnetic fields.

Figure 6 shows the dependence of angular velocity on the aspect ratio of the uric acid crystals dia-magnetically rotating around the applied magnetic fields of up to 500 mT. No apparent dependence of the orientation speed on the aspect ratio was obtained. Probably mixing crystal plates with different size and area randomized the possible dependency.

In order to exclude the effects of the fluctuations of area size, we calculated the new parameter, aspect ratio per area, as shown in Figure 7. The angular velocity of diamagnetic rotation clearly increased when the aspect ratio being divided by area of crystal increased. The results of analyses indicated that the orientation speed of crystal was large when the crystal area is small, i.e. the averaged moment of inertia decreased. It was also speculated that the aspect ratio definitely had an effect on the angular velocity, however, the dispersion of crystal size unrevealed its dependency.

The crystal of uric acid showed orientation under magnetic fields. In the future study, it is needed to clarify the structure of the obtained crystals by X-ray crystal structure analysis for the purpose of revealing the more detailed mechanism.

IV. A MODEL FOR THERAPEUTIC APPLICATION

Here we propose a model to produce a new therapeutic method for the treatment of gout. We consider a situation where needle types of uric acid crystals are growing in an arthrosis of thumb, as shown in Figure 8. The growing uric acid crystals can be aligned by the external magnetic fields of several hundred of Tesla. The alignments of diamagnetic fiber-like materials by means of diamagnetic torque rotation can cause the polymerization of fiber-like crystals of uric acid, consequently, the grown-up large crystal assembly should appear as less spiny and more rounded micro- to millimeter size of crystals, which will bring less pain to the arthrosis of thumb. The rough model for the diamagnetic alignment of micro-crystals of uric acid is shown in Figure 9.

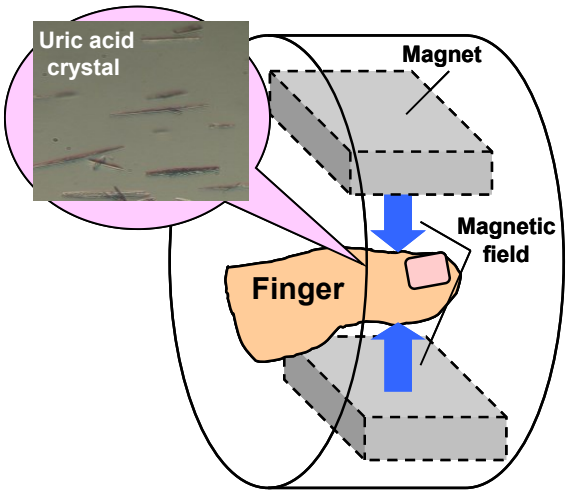

Figure 8. A new therapeutic method for the treatment of gout.

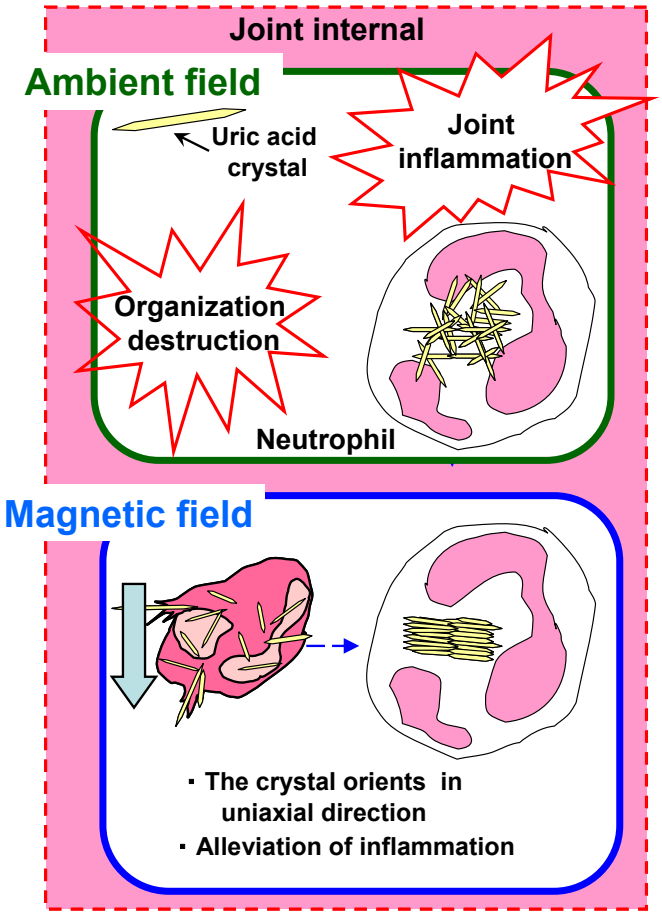

Figure 9. Rough model for the diamagnetic alignment of micro-crystals of uric acid. Upper; under the non-magnetic treatment condition, spiny assembly of needle like uric acid crystals can easily penetrate the cell tissues, Lower; magnetic field exposure at ~500mT can form a less spiny assembly, which can reduce the damage to the surrounding cellular tissue.

V. Conclusions

Crystals of uric acid were re-crystallized from uric acid powder under a saturated aqueous solution. By utilizing an electromagnet with a maximum field of 500mT, the crystals were oriented perpendicular to the magnetic fields.

An analysis of angular velocity of the uric acid crystals dia-magnetically rotating around the applied magnetic fields of 200mT – 500mT was carried out. It was revealed that the angular velocity depended on magnetic fields and crystal's aspect ratio per area.

Acknowledgment

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References

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