J. Condensed Matter Nucl. Sci. 28 (2019) 1–6

Research Article

An Experiment in Reducing the Radioactivity of Radionuclide (^{137}Cs) with Multi-component Microorganisms of 10 Strains

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Abstract

In order to observe the effect of multi-component microorganisms on the radiation intensity of a radioactive ^{137}Cs solution, a multi-component microorganism composed with 10 strains was designed and utilized in the experiment. It was composed of the radioactivity resistant *Bacillus spp*., aerobic bacteria which have a high temperature resistant and good biodegrade ability, anaerobic lactic acid bacteria, highly resistant to toxicity and good polymer degradable yeast, and photosynthetic strains with a better utilization of proton and high production rate of H^+. An amount of 120 ml of this multi-component microorganism was mixed with 380 ml of deionized water. An amount of 0.159 ml of hydrochloric acid solution (0.1 mol/l) containing ^{137}Cs was added to this mixture to adjust the final radioactivity to be 50 kBq. The mixed 500 ml samples were irradiated at 12-hour intervals with light and shaken at about 120 rpm at 25°C in a shaking incubator. (continued on p. 2)

Keywords: Biological transmutation, ^{137}Cs, Gamma-ray count rate, Multi-component microorganisms, Radioactivity

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(continued from p. 1) The radioactivity of the mixed solution was measured by a counter equipped with a high-purity Ge detector every other or 3 days. It was observed that the radiation intensity increased slightly at the beginning and then decreased to the 80% level compared to the control.

1. Introduction

In 1989, Martin Fleischmann and Stanley Pons reported that an electrolytic cell produced anomalous heat of a magnitude that could not be due to anything but nuclear processes [1]. Since then, many researchers have tried to reproduce their results and debated on its mechanism for almost 30 years. The mechanism is still not yet clear, however, the phenomenon is characterized by two facts; i.e., excess heat generation and nuclear transmutation. It has been renamed lattice assisted nuclear reaction (LANR), low-energy nuclear reactions (LENR) or condensed matter nuclear science (CMNS). Nuclear transmutation was confirmed through the comparison of the surface composition of the palladium electrode before and after the experiment. From these results, it can be understood that a nuclear reaction at low energy level is possible; reactions are not limited to the typical high energy nuclear reaction.

This phenomenon, LENR, provided a motivation to look at biological transmutations from different aspects which has been totally ignored by the scientific community [2]. Actually, it has been reported by a few pioneers from the early 19th century that biological transmutation occurs in a living body [3]. Among them, Kervran carried out a systematic approach to this phenomenon and reported it in his book, "Biological Transmutation" [4].

His experimental results were critiqued because of imperfect mass control, and Komaki carried out experiments using microorganisms to confirm the phenomenon of biological transmutation [5]. Microorganisms are much smaller than large sized fauna and flora and the change in mass balance and analysis can be monitored under strict conditions. Komaki studied eight kinds of microorganisms, including *Aspergillus niger* (IFO No. 4066), *Penicillum chrysogenum* (IFO No. 4689), *Rhizopus nigricans* (IFO No. 5781), *Mucor rouxii* (IFO No. 5773), *Saccharomyces cerevisiae* (IFO No. 0308), *Torulopsis wills* (IFO No. 0396), *Saccharomyces ellipsoideus* (IFO No. 0213), and *Hansenula anomala* (IFO No. 0118). He used specially designed culturing media such as Fe, K, Mg, and Ca deficients media to observe any change in the composition of media after the culturing and the behavior of the microorganisms with the insufficient supply of specific mineral elements. It was confirmed that biological transmutation occurred in a way that the microorganisms produced the necessary elements through transmutation. These results strongly support the previous observations of Kervran on biological transmutation, and it seems that it is a more general phenomenon which may occur in almost all living organisms including microorganisms.

Recently, Vysotskii and Kornilova showed more evidence for biological transmutation using modern spectroscopic techniques [6]. In particular, they used Mössbauer spectroscopy, which distinguishes isotopes of elements with good sensitivity. The experiments were performed with bacteria, including; *Bacillus subtilis, Escherichia coli*, *Deinococcus radiodurans*, as well as a yeast culture *Saccharomyces cerevisiae*.

When manganese was introduced by adding an $MnSO_4$ solution, a clear peak of ^{57}Fe was measured, indicating that manganese had been transmuted into iron. In natural iron,^{57}Fe represents only 2.1% of the total iron content and there is no possible interference with any other element. In another analysis by time-of-flight mass spectroscopy, the mass 57 peak was as large as that of mass 56, the most abundant iron isotope. This is another confirmation of the production of ^{57}Fe.

When the bacteria were cultured in a medium without iron, they produced an ^{54}Fe peak as large as ^{56}Fe after the bacteria grew. In natural iron,^{54}Fe represents only 5.8% of the total iron content. Vysotskii and Kornilova proposed the following reaction to explain the formation of ^{54}Fe:

$$^{23}\mathrm{Na} + {}^{31}\mathrm{P} \rightarrow {}^{54}\mathrm{Fe}.$$

After confirming the biological transmutation, they felt to carry out an experiment to observe the transmutation of radioactive elements. In principle, if biological transmutation is possible, there is no reason to think it will not work for radioactive elements, except that the microorganisms may be killed due to the exposure of strong radiation such as gamma rays. And, in fact, Vysotskii and Kornilova have successfully observed the biological transmutation of ^{137}Cs radioactive element.

$$^{133}\mathrm{Cs} + \ ^{1}\mathrm{H} \rightarrow \ ^{134}\mathrm{Ba}.$$

Additionally, they also observed that the rate of biological transmutation was increased up to 20 times depending on the inorganic salts added to the culturing media. However, it was observed that using a single species of microorganisms is not so effective in increasing the efficiency of biological transmutation because the microorganisms could not sustain life for long time. To overcome this difficulty, they adopted multi-component microorganisms composed of hundreds of different species in a symbiotic state. The multi-component microorganisms showed much stronger resistance to the exposure of radiation due to their strong ecosystem. They could extend the life of the microorganisms three times longer compared to the single species of microorganisms. It was found that ^{137}Cs, which has a radioactive half-life of 30 years, transmutes within 310 days into stable ^{138}Ba. They proposed the nuclear reaction as:

$$^{137}\mathrm{Cs} + \ ^{1}\mathrm{H} \rightarrow \ ^{138}\mathrm{Ba}.$$

These are the best experimental proofs of biological transmutation heretofore, and they show the promising application of microorganisms for the treatment of radioactive nuclear waste. However, the details of the composition of multi-component microorganism are not known yet, and this hinders the reproduction of the experiments. In addition to this, it is difficult to study the mechanism of biological transmutation without knowing the composition of microorganisms.

To resolve this problem, we designed a multi-component microorganism with a small number of different species. By this approach, the study on the mechanism of biological transmutation can be easier. The multi-component microorganisms were prepared by the Coenbio Research Institute, which has been developing bioremediation technologies for treating soil and groundwater contaminated with toxic heavy metals for over 10 years. The microbial products developed by the institute have been applied to large-scale contaminated soil such as at abandoned mines and contaminated river sedimentation sludge. We have obtained a promising result in preliminary experiments showing that multi-component microorganisms with less than 10 microorganism species can be utilized for the treatment of nuclear waste treatment.

2. Materials and Methods

In order to study the change of ^{137}Cs radiation intensity by microorganisms, 10 specific strains of microorganisms were selected and the mixed microorganism system was designed. It was composed of the radiation resistant *Bacillus* spp., aerobic bacteria which have a high temperature resistance and good biodegrade-ability, yeast which is highly resistant to toxicity and has a good polymer decomposition capability, and photosynthetic strains with a good utilization of proton and high production rate of electron and H^{+}. These microorganisms were dissolved in a solution.

A solution contain ^{137}Cs was dissolved in hydrochloric acid (0.1 mol/l) to make its radioactivity to be about 100 Bq/g. The experimental samples of 500 ml were prepared by mixing 120 ml of the solution of microorganisms and 380 ml of deionized water. To this mixture, 159 μl of hydrochloric acid containing ^{137}Cs was added to make the total radioactivity of the sample 50 kBq. This sample was poured into a 1-liter capacity Erlenmeyer flask (Fig. 1). The prepared samples were irradiated at 12-hour intervals with room light and shaken at about 120 rpm at 25°C in a shaking incubator. The gamma rays from the mixed solution was measured every other or 3 days with a counter equipped with a high purity p-type Ge detector having relative detection efficiency of 70%. Figure 2 shows the arrangement of the flask in a custom designed holder above the detector.

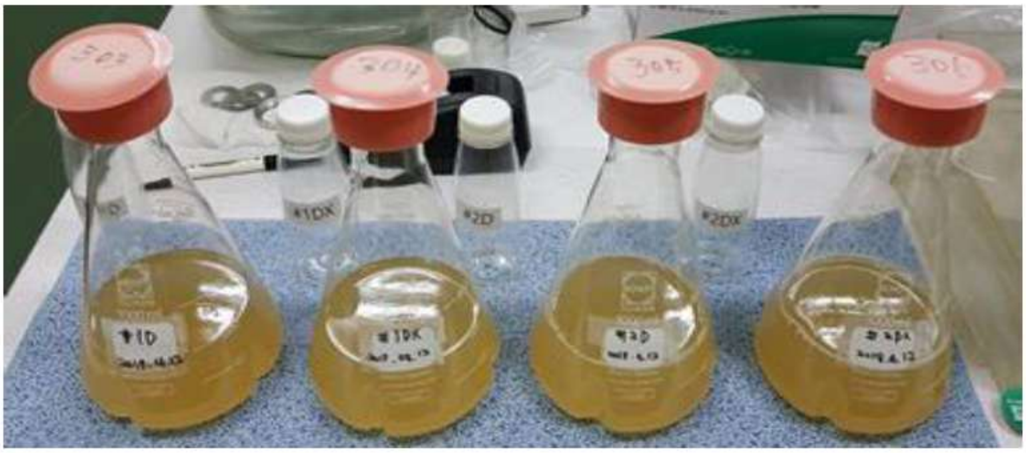

Figure 1. The prepared samples (500 ml) with mixed microorganisms and 50 kBq of ^{137}Cs.

3. Results and Discussion

Figure 3 shows the result of count rate measurements. It is clearly demonstrated that the gamma-ray intensity from ^{137}Cs has been decreased to the level of less than 90% compared to the initial level. Interestingly, the count rate increased by 8% at the beginning and then it began decreasing. This is the same tendency which was observed by Vysotskii and Kornilova [6]. The control sample did not show any change in the level of the activity until the experiment was finished.

The unique pattern of count rate variation, increase and then decrease, implies that there would be two different mechanisms in biological transmutation. They may be related to the acceleration of ^{137}Cs decay and transmutation, respectively. The analysis on the composition of the sample is undergoing and we focused on the observation of ^{138}Ba,

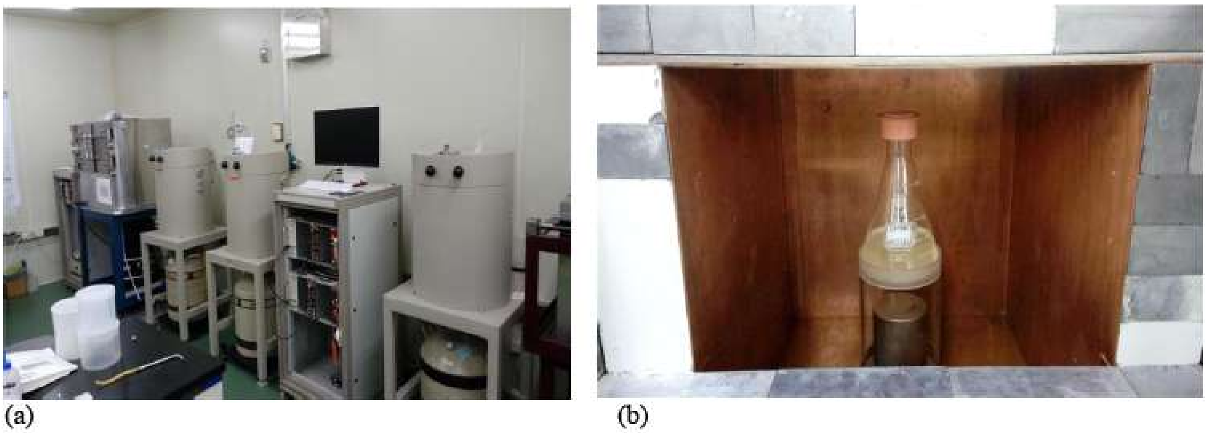

Figure 2. The experimental setup equipped with high-purity Ge detector (a), and the sample flask above the detector (b).

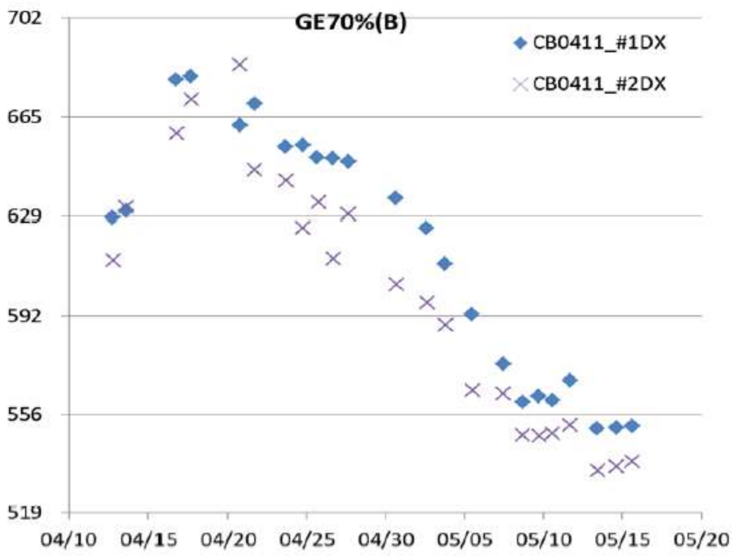

Figure 3. The change of γ-ray counting rate (s^{-1}) from ^{137}Cs over time (month/day).

which can be a solid evidence of biological transmutation of ^{137}Cs as explained above.

This result shows that multi-component microorganisms can be utilized for the remediation of soil and groundwater contaminated with radioactive materials, and to restore the contaminated ecosystem. Further experiments will be carried out to explore the mechanism of biotransmutation.

4. Conclusion

It has been shown that a multi-component microorganism with a smaller number of species, less than 10 kinds of species, can be effectively utilized for the decrease of radioactivity of ^{137}Cs. This phenomenon is an additional evidence of biological transmutation and it seems that there are two stages of reaction in biological transmutation. Acceleration of decay occurs first and is then followed by an overall decrease in the counting rate.

Acknowledgment

This research was supported by the National Research Foundation of Korea (NRF) funded by the Ministry of Science and Technology 2017M2B2A9071803.

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