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Direct Fixation of Atmospheric CO_2 towards Chemical Synthesis of Fuel Hydrocarbon

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Abstract

We have reported that fuel hydrocarbon was chemically synthesized from CO_2 and activated water. In this report, we show the direct evidence of CO_2 fixation from air. CO_2 in the air is composed of about 99 % ^{12}C, about 1% ^{13}C, and about one trillionth radioisotope ^{14}C. The extremely trace amount of ^{14}C was measured with liquid scintillation counter by following beta-decay. The newly synthesized hydrocarbon revealed 14.6 dpm/gC. These facts clearly demonstrate direct fixation of atmospheric CO_2 toward hydrocarbon synthesis.

Keywords: CO_2 fixation, Measurement of ^{14}C, Beta-decay of ^{14}C, Fuel hydrocarbon

Abbreviations: TD-Tetradecane, CLO-Commercial Light Oil, AC1~10-Amplification cycle 1~10, DPM-Disintegration Per Minute

Introduction

Our planet is in trouble because of global warming, the heating of earth's surface, oceans and atmosphere. Glaciers are melting, sea levels are rising, and wild fires and heat waves are getting more severe. Carbon dioxide is one of the major greenhouse gases. To avoid global warming, a significant shift from "low carbon" to "decarbonization" society is necessary. From this standpoint, we have published chemical synthesis of fuel hydrocarbon from CO_2 and activated water [1]. In fossil materials such as all mineral oil or the products, the ^{14}C contents could decay over millions of years, therefore no ^{14}C can be detected anymore [2]. On the other hand, in fixation of atmospheric CO_2, the synthesized organic materials should contain ^{14}C. In the chemical synthesis of oil, origin of CO_2 was thought to be atmospheric air, but scientific evidence was not proved. CO_2 in the air is composed of about 99% ^{12}C, about 1% ^{13}C, and about one trillionth radioisotope ^{14}C. Firstly, we tried to use ^{13}C-CO_2. However, noise of background was not negligible. Thereafter, we decided to measure beta-decay of ^{14}C incorporated in newly synthesized hydrocarbon.

Materials and Methods

According to the previously mentioned method (1), new oil was synthesized as follows. In this process, oxygen gas is converted to ozone, and further to reactive oxygen species such as superoxide anion radicals and hydroxyl radicals. The reactive oxygen species may reduce carbon dioxide to carbon monoxide, as follows,

$$2CO_2 \Rightarrow 2CO + O_2 \qquad \text{reaction 1}$$

By using TiO_2 photocatalyst, H_2O was decomposed into H_2 and O_2 as follows,

$$2H_2O \Rightarrow 2H_2+O_2 \qquad \text{reaction 2}$$

As a total,

$$CO_2+H_2O \Rightarrow CO+H_2+O_2 \qquad \text{reaction 3}$$

The oil generation reaction may occur as radical polymerization in emulsion and be written as follows,

$$nCO+(2n+1)H_2 \Rightarrow C_nH_{2n+2}+nH_2O \qquad \text{reaction 4}$$

At each amplification cycle, volume and weight of oil and activated water were measured before and after the cycle. Then real increase of oil was recorded. Oil should be added in this reaction, because it is a template synthesis [1]. Analytical data and characteristics of newly generated oil and original oil have been compared and reported in this journal [1]. Concentration of the atmospheric CO_2 is 407 ppm which was reported by world meteorological organization in 2019 (https://gaw.kishou.go.jp/) [3].

After each cycle of oil amplification, 10 ml sample was mixed with 10 ml of scintillation cocktail (Ultima Gold F, PerkinElmer, USA). Hitachi ALOKA Accuflex LSC-7200 was used for scintillation counting. Measurement time was 300 min. Since hydrocarbon is week quencher, the newly synthesized oil was measured as soon as possible for liquid scintillation counting. Carbon content of oil was measured by using MICRO CORDER JM11 (J-SCIENCE LAB CO) and Flash Smart Organic Elemental Analyzer (Thermo Fisher Scientific CO). Weighing balance used was MSA 2.7S-000-DM (SARTORIUS JAPAN CO).

Results and Discussion

Chemical synthesis of hydrocarbon

Commercial light oil was purchased from gasoline station and used for first chemical synthesis of hydrocarbon. The mixture of original light oil and newly synthesized oil is called as Amplification Cycle 1 (AC1). AC1 sample was used for the second synthesis. Likewise, the chemical synthesis was repeated ten times (from AC1 to AC10). Volume and weight of oil and activated water were carefully measured before and after each cycle. The increased % of oil (indicated as red circle) was accumulated ten times (**Figure 1**). The total increase of AC10 was around 46.2 %.

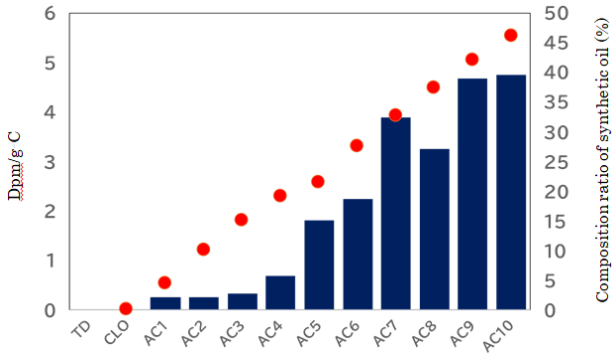

Figure 1: Result of DPM measurements. The increased % of oil (indicated as red circle) was accumulated ten times.

Measurement of ^{14}C in synthesized hydrocarbon

Since the amount of ^{14}C in the atmospheric CO_2 is about one trillionth, the extremely low concentration of radioisotope ^{14}C has to be measured with Liquid Scintillation Counting (LSC) [3]. The direct measurement of an organic sample in the LSC is always advantageous if a sample such as newly synthesized oil can be dissolved in the scintillation cocktail such as Ultima Gold F (PerkinElmer, USA). The organic sample should also show no or only little color. We adopted extremely long counting times (300 min). The incorporation of ^{14}C into new oil increased as amplification cycle increased (Figure 1). About 4.6 dpm/gC was determined at 46.2% increase of oil, where carbon content of oil was measured as 86.04%. As the volume of original fossil oil was increased up to 1.462 times, real value of true incorporated radioisotope in synthesized oil is 4.6 × 1.462 ÷ 0.462=14.6 dpm/gC. When ^{14}C content in ethanol of Japanese wine was measured, the average content was 15.1 dpm/gC [4]. It was also reported that ^{14}C content in ethanol of various liqueurs including brandy, whisky, vodka etc. ranged from 16 to18 dpm/gC [5]. Therefore, 14.6 dpm/gC of oil is nearly the same level with biogenic material. These data clearly shows that atmospheric CO_2 was fixed to form new oil. It is sure that a series of these experiments contribute to carbon neutrality.

Conclusion

The ^{14}C content of newly synthesized hydrocarbon was measured by liquid scintillation counting. These data clearly showed that atmospheric CO_2 was directly fixed into hydrocarbon. This process must contribute to decarbonization society in the future.

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