MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2012B0207 実験課題名 Title of experiment Study on muon transfer process in the liquid phase 実験責任者名 Name of principal investigator Kazuhiko Ninomiya 所属 Affiliation Osaka University	装置責任者 Name of responsible person Yasuhiro Miyake 装置名 Name of Instrument/(BL No.) D2 実施日 Date of Experiment 2012/12/24-26

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

C_6H_6 + CCl_4 (3% and 33%) mixture, C_6H_6, CCl_4.

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

A muonic hydrogen is one of the simplest exotic atom that consists of a muon and a proton. The charge of a proton is strongly shielded by a muon in the muonic hydrogen because the mass of a muon is 206 times larger than that of an electron. The muonic hydrogen can diffuse in the substance like a neutron and approach another nucleus easily. Then, the muon is trapped deeper bound state in the heavier nucleus and transferred to the muon atomic orbit of another atom. This process is known as a muon transfer process. The transfer process occurs also in the case of a pionic hydrogen, which consists of a pion and a proton.

In our previous study on pion transfer process, we investigated a chemical effect in mixtures of liquid samples. Pion transfer process occurs only from excited pionic hydrogen because lifetime of ground-state (1s state) pionic hydrogen is very short. On the other hand, muon transfer process also occurs from ground-state muonic hydrogen due to long lifetime of muonic hydrogen. By comparing transfer processes from pionic and muonic hydrogen atoms, we can investigate the contribution for chemical effect in transfer process from ground-state and excited-state exotic atoms separately. In this work, we performed muon irradiation for C_6H_6 + CCl_4 and C_6H_{12} + CCl_4 system and examined chemical effect for muon transfer from ground-state muonic hydrogen.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

We selected the following samples for measurement; C_6H_6 + CCl_4 (3% and 33%) mixture, C_6H_{12} + CCl_4 (3% and 33%) mixture, pure C_6H_6, pure C_6H_{12}, and pure CCl_4. These samples were sealed in the aluminum boxes with 10 mL volume. Muonic X-rays, which are emitted after formation of muonic atoms, were measured by Ge detectors to determine muon capture probability for each atom.

Figure. 1 shows the experimental muonic X-ray spectrum for C_6H_{12} + CCl_4 (33%) sample. Muonic X-rays originated muon capture in carbon and chlorine atoms were clearly found. The relative intensity of Cl (5–3) / Cl (4–3) and Cl (4–2) / Cl (3–2) in C_6H_{12} + CCl_4 mixture sample was smaller than that in pure CCl_4 sample. The difference indicates that initial state (principal and angular momentum quantum number) of the muon captured by chlorine atom in C_6H_{12} + CCl_4 mixture sample is different from that in pure CCl_4 sample. Because the muon transfer occurs in C_6H_{12} + CCl_4 mixture sample while no muon transfer in pure CCl_4 sample, it seems that the muon transfer process changes the initial state of the muon captured by chlorine atoms in C_6H_{12} + CCl_4 sample. In fact, some differences on muon initial states by muonic atom formation processes have been reported previously [2]. On the other hand, in C_6H_6 + CCl_4 sample, although the muon transfer also occurs, the muonic X-ray structure of that was similar to pure CCl_4 sample.

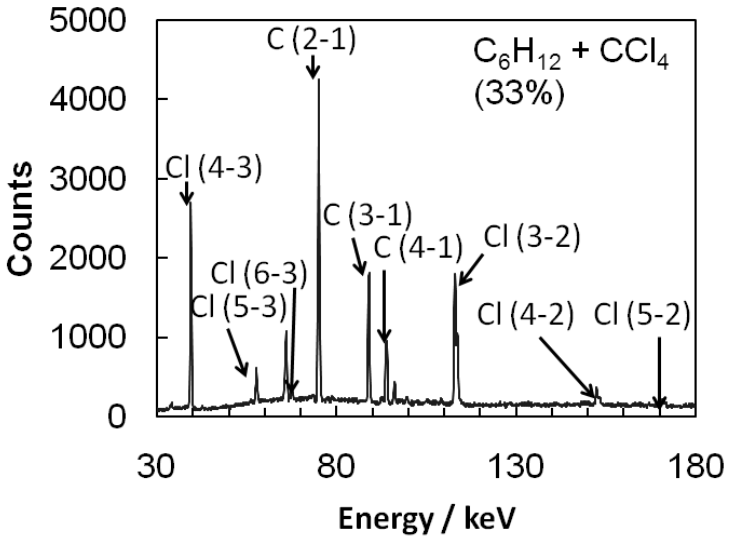

Fig. 1.: Muonic X-ray spectrum for C_6H_{12} + CCl_4 (33%) sample. Cl (n-n') means muonic Cl X-ray emitted with muon deexcitation from principal quantum number n to n'.