Versatile target formation method for water soluble compounds

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Intermediate-energy ($E_{beam} \geq 100$ MeV/nucleon) charge-exchange (CE) reactions, such as (^{3}He, t), at forward angles including $\theta = 0^\circ$ are used to search for Gamow-Teller (GT) transitions. In the (^{3}He, t) reaction, the magnetic spectrometers are widely used to analyze the out going tritons [1]. Targets are placed at the fixed object point of the spectrometer, which is usually inside the scattering chamber, and beams are sharply focused on them. In order to achieve a good energy resolution ($\Delta E \leq 50$ keV), it is requested that the energy loss and the energy struggling should be small in the targets. Therefore thin foils with a thickness less than 2 mg/cm^2 are preferable. Except for chemically stable malleable metals, however, thin foils are not easily obtained. Our aim is the targets of chlorine, sodium and potassium. Chlorine is usually gas, while sodium and potassium are chemically reactive and soft metal. It is not easy to form them as thin self-supporting targets. We developed a new methods to make targets of thin film including chlorine, sodium or potassium by using polyvinylalcohol (PVA) as a supporting material.

The stable isotopes of chlorine, sodium and potassium have relatively small negative Q values in CE reactions. On the other hand, ^{12}C and ^{16}O nuclei have very large negative Q values. Therefore even though the polymer of organic compounds are used as the supporting material, the spectroscopic information on chlorine, sodium or potassium are obtained up to the excitation of the Q value difference. The supporting material should be easily formed as a thin film. The organic compound PVA have convenient feature that it is soluble in water. By drying the solution on a flat plate, a flexible film is formed. The PVA can easily mix with materials soluble in water. Even if the chemical compound is not soluble in water, the PVA can support the powdered compound and a thin film can be formed.

We selected chemical compounds, which were calcium chrolide (Ca_2Cl_2), sodium carbonate (Na_2CO_3) and potassium carbonate (K_2CO_3). The calcium chloride includes Ca of which the main component is ^{40}Ca. It does not interfere with the attractive region of the energy spectra for chlorine target because the ^{40}Ca has large Q value with -14.3 MeV. These three chemical compounds are all soluble in watter. It should be noted that the calcium chrolide is strongly deliquescent. Therefore, the calcium chrolide need some special treatments.

In making a film with calcium chlolide, we used PVA with higher polymerization of 2000, because we found that the film PVA+$CaCl_2$ using higher polymerization was able to better resist to humidity. The solutions of $CaCl_2$ (12 mg/ml) and PVA (12 mg/ml) were prepared. To disolve PVA the water was heated nearly up to 100 °C. The solutions of $CaCl_2$ and PVA were mixed with a ratio of one to one. By drying this solution poured on a glass petri dish, we obtained films with $CaCl_2$. The dried film, however, titely atached to the glass and it was very hard to peel off. Glass petri dish was not suitable. Therefore a special dish was

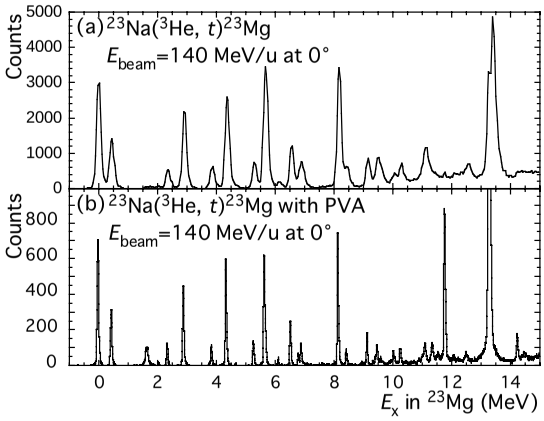

Figure 1: The ^{23}Na(^{3}He, t)^{23}Mg spectra. The spectrum (a) was obtained by using a sodium metal target. The spectrum (b) was obtained by using the Na_2CO_3+PVA target. The event with θ_{scat} <0.8° were selected. An excelent energy resolution of 45 keV (FWHM) was achieved.

prepared. The bottom part of this dish was a fluorin resin sheet (Teflon) with a thickness of 1 mm. The wall part was a ring made by brass with an inside diameter of 40 mm. The ring was placed on the sheet and they were fixed by clips. The mixed $CaCl_2$ and PVA solution (3 ml) on the dish was dried in a globe box under the dry N_2 gass atmosphere. In order to absorb vapor, P_2O_5 was put in the box, which have stronger absorbency of water than $CaCl_2$. The dried film sticked to the ring tightly. The Teflon sheet was removed by bending the sheet. The film was shaped and mounted on a target holder. By this way we could make films of $CaCl_2$+PVA with a total thickness ∼2 mg/cm^2.

It was easier to make Na_2CO_3 or K_2CO_3 films than $CaCl_2$ because of no deliquescence. The solutions of Na_2CO_3 (56 mg/ml) and K_2CO_3 (56 mg/ml) were prepared. The solutions of PVA (50 mg/ml) in water was also prepared. The Na_2CO_3 and K_2CO_3 solutions were mixed with the PVA solutions, respectively, with a ratio of one to one. The solutions (2 ml) were poured to glass petri dishes with an inside diameter of 70mm. The solutions were dried in the air. The educts of Na_2CO_3 and K_2CO_3 powder appeared, and the films became like frosted glass although the pure PVA film was transparent. However, powder was evenly supported in the PVA films. We could make films of Na_2CO_3+PVA and K_2CO_3+PVA with thickness 1.6 mg/cm^2 and 1.0 mg/cm^2, respectively.

We performed an high resolution (^{3}He,t) experiment by using WS course [2] to test the targets. A 140 MeV/nucleon ^{3}He beam was used to bombard them. The ejectile tritons were analyzed by the spectrometer Grand Raiden set at 0°. In order to realize good energy resolution, the dispersion-matching technique was used for beam transportation [2, 3, 4]. We obtained ^{nat}Cl(^{3}He, t)K, ^{23}Na(^{3}He, t)^{23}Mg and ^{nat}K(^{3}He, t)Ca spectra with an excelent energy resolution of 45 keV (FWHM). These spectra were clean enough to study GT states because the main parts of contaminations did not appear in the lower excited region by the difference of Q values, as we see from Fig. 1.

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