Fusion in $^6$Li + $^{197}$Au at near barrier energies

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Introduction:

The study of effect of breakup on fusion processes with weakly bound nuclei at near barrier energies has gained importance in recent years [1]. In order to gain insight into the influence of the projectile structure on the fusion process, we have carried out measurements with $^6$Li on $^{197}$Au. Amongst stable nuclei, $^6$Li has the lowest breakup threshold $S_{\alpha/d}=1.475$MeV. In this paper we present fusion excitation function of $^6$Li + $^{197}$Au over the energy range $0.8 \leq E/V_b \leq 1.5$. The fusion excitation function for $^7$Li ($S_{\alpha/t}=2.45$MeV) + $^{197}$Au over a range $0.6 \leq E/V_b \leq 1.5$ was reported earlier [2].

Experimental Details:

The experiment was performed at Pelletron LINAC facility, Mumbai with $^6$Li beam of 10-20 pnA. The targets of $^{197}$Au foils of thickness 1.25-2 mg/cm$^2$ were irradiated at beam energies from 26MeV to 44MeV in steps of 2MeV. The experimental setup and offline data collection procedures are similar to the earlier measurement [2]. For efficient use of beam time, two cascaded targets with Al foil of appropriate thickness as a degrader (~1-3 MeV loss) were used in this experiment. The energy after the degrader was calculated using TRIM [3]. At lowest energies the data was collected in a close geometry inside the lead house.

Table 1 lists the characteristic $\gamma$-rays and half-lives of different reaction products. All the fusion and transfer products could be clearly identified and half-lives also have been verified.

![Figure 1: Measured excitation function (symbols) for residues from complete fusion in $^6$Li+$^{197}$Au reaction together with statistical model PACE calculations (lines).](image)

The excitation functions of the direct reaction channels namely, 1n-pickup and 1n stripping are shown in figure 2. In case of a d/t transfer, the products (Hg isotopes) are stable and could not be measured by present technique. However, $^{197}$Hg ($13/2^+$) arising from (d,2n) is observed.

Table 1: Characteristic $\gamma$-rays and half-lives

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>$E_\gamma$(keV)</th>
<th>$T_{1/2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{201}$Pb (2n)</td>
<td>331.15</td>
<td>9.33 hrs</td>
</tr>
<tr>
<td>$^{200}$Pb (3n)</td>
<td>257.19, 268.36</td>
<td>21.5 hrs</td>
</tr>
<tr>
<td>$^{199}$Pb (4n)</td>
<td>353.39, 720.24</td>
<td>90 min</td>
</tr>
<tr>
<td>$^{198}$Pb (5n)</td>
<td>173, 290</td>
<td>2.4hrs</td>
</tr>
<tr>
<td>$^{198}$Au (1n-stripping)</td>
<td>411.8</td>
<td>2.69 days</td>
</tr>
<tr>
<td>$^{196}$Au (1n-pickup)</td>
<td>333.03, 355.7</td>
<td>6.17 days</td>
</tr>
<tr>
<td>$^{197}$Hg (d,2n)</td>
<td>134</td>
<td>23.8hrs</td>
</tr>
</tbody>
</table>

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Figure 2: Measured excitation function for 1n-stripping (198Au) and 1n-pickup (196Au) reaction. As can be seen from figure 2, the 1n-stripping cross-section is larger than 1n-pickup.

Figure 3: Reduced cross-sections for compound nuclear fusion in 6Li and 7Li with 197Au (Errors are smaller than the symbol size)

Figure 3 shows the reduced cross-sections for both 6Li and 7Li on 197Au as a function of scaled energy. The barrier parameters are derived from Akyüz Winther potential. It can be seen that there are no significant differences in reduced fusion cross-sections of 6Li and 7Li. The coupled channel calculations and the barrier distribution will be presented.

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References: