# New Titanium Production Process

**High-speed Titanium Production Process Using Titanium Subhalides**

**Environmentally Sound Process Utilizing Titanium Scraps**

## High-speed Ti production process

### Ti production process using Ti subhalides \( (\text{TiCl}_x, \ x = 2, \ 3 \ ) \)

- \( \text{TiCl}_x(l,\ g) + \text{Mg}(l,\ g) \rightarrow \text{TiCl}_x(s,\ l) + \text{MgCl}_2(l) \)
- \( \text{TiCl}_x(l,\ g) + \text{Ti}(s,\ \text{scrap}) \rightarrow \text{TiCl}_x(s,\ l) \)

### Step 1: Production and enrichment of \( \text{TiCl}_x \)

\[ \text{TiCl}_4(l,\ g) + \text{Mg}(l,\ g) \rightarrow \text{TiCl}_x(s,\ l) + \text{MgCl}_2(l) \]

### Step 2: High-speed reduction of \( \text{TiCl}_x \)

- \( \text{TiCl}_x(s,\ l) + \text{Mg}(l,\ g) \rightarrow \text{Ti}(s) + \text{MgCl}_2(l,\ g) \)

- **Utilization of Ti scraps**

- **High-speed reaction**

### Step 3: Removal of reaction product \( \text{MgCl}_2 \)

- **High-purity Ti can be produced.**

- **Ti vessel together with product Ti can be directly melted without crushing.**

### Features and experimental result

**Comparison of Kroll process and new process**

<table>
<thead>
<tr>
<th></th>
<th>Kroll process</th>
<th>New process</th>
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</thead>
<tbody>
<tr>
<td>Process type</td>
<td>Batch-type, limited speed</td>
<td>(Semi-)Continuous, high-speed</td>
</tr>
<tr>
<td>Feed material</td>
<td>( \text{TiCl}_4(l,\ g) ) \quad \text{TiCl}_2, \text{TiCl}_3(s,\ l) )</td>
<td></td>
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<tr>
<td>Heat of reduction</td>
<td>High ( (\Delta H = -434 \ \text{kJ mol}^{-1}) ) \quad Low ( (\Delta H = -94 \rightarrow -191 \ \text{kJ mol}^{-1}) )</td>
<td></td>
</tr>
<tr>
<td>Reactor material</td>
<td>Mild steel (Iron contamination unavoidable)</td>
<td>Titanium (No iron contamination)</td>
</tr>
<tr>
<td>Reactor size</td>
<td>Large (Crush and melt)</td>
<td>Small (No crush and direct melt)</td>
</tr>
<tr>
<td>Flux, sealant</td>
<td>Not used</td>
<td>Ti, MgCl_2</td>
</tr>
</tbody>
</table>

**Common features**

- Magnesiothermic reduction of chlorides
- Removal of MgCl_2 and Mg from Ti sponge by vacuum distillation
- Production of high-purity Ti with low oxygen content

**Obtained Ti sponge**

- Ti with 99.2% purity was efficiently obtained using Ti vessel.

**Feasibility of new Ti production process based on the magnesiothermic reduction of Ti subhalides using Ti vessel was demonstrated.**

## Resource Recovery and Materials Process Engineering Laboratory

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