



Fig.3. Molecular rocket reaction $TcCp_2$

Another interesting phenomenon associated with implantation reaction by nuclear recoil is collision-cascade enhancement of displacement yield. This was previously observed in metal β -diketonates, but has been recently found in metallocene also. One order of magnitude higher displacement yield of the recoil atom could be obtained in implanted β -diketonates compared to hot atom reaction. This could be ascribed to shock-wave phenomena with high pressure and high temperature pulses in the moment of recoil implantation.

3. Molecular Rockets and shock waves induced by nuclear reactions

Molecular rockets and shock waves induced by nuclear reactions were interesting findings in our laboratory in Gendai.

Molecular rockets obtain energy from nuclear recoil in the moment of nuclear transformation occurring at the central atom of metallocene included in β -cyclodextrin. A metallocene molecule ejected from the cavity of β -cyclodextrin undergoes unique chemical reactions: molecular impact, molecular ablation, molecular excitation and molecular rearrangement. In the case of $^{102}Ru(Cp)_2$ reaction in ruthenocene $Ru(Cp)_2$ included in β -cyclodextrin, a molecular rocket of $TcCp_2$ radical will pick up cyclopentadienyl radical from other ruthenocene (Fig. 3).