Equipment Development Center

VIII-I Development of "IMS Machines"

The technical staff of the Equipment Development Center is partly engaged in planning, researching, designing and constructing "IMS machines." This machine, crowned with the acronym of the Institute for Molecular Science, is a high-tech experimental instrument, with emphasis on new technical idea and co-operative work with members inside and outside the Institute including those in industries. We collect suggestions of new instruments once every year from all of the members of IMS.

In this fiscal year, 2000, two project themes (1 thorough 2) were adopted as IMS machines. IMS machine projects 3 (IMS machine 1999) was completed, and project 4, 5 (IMS machine 1999) are under way.

1. **A Novel Method for Intensefying Oriented Molecular Beam: Electrostatic Honeycomb Filed**
   (proposed by SHIMIZU Yuichiro, CHE Dock-Chill, HASHINOKUCHI Mitihiro, SUZUI Mitsukazu, WATANABE Michio and KASAI Toshio)
2. **The Development of a Photoion and Photoelectron CMOS Imaging Detector with High Repetition Rates**
   (proposed by GEJO Tastuo and YOSHIDA Hisashi)
3. **Vacuum-Chamber-Based High Voltage Application Apparatus to Fabricate Wide-Range Nonlinear Optical Wavelength Converters**
   (proposed by KURIMURA Sunao, TAIRA Takunori, KOBAYASHI Kazuhiro and SUZUI Mitukazu)
4. **Sorption-Pump-Type Large-Scale Dilution Refrigerator**
   (proposed by SHIBAYAMA Hideo and KONDOH Takuhiko)
5. **High-Speed Array Detector**
   (proposed by Kazuo WATANABE and Hisashi YOSHIDA)

VIII-I-1 A Novel Method for Intensefying Oriented Molecular Beam: Electrostatic Honeycomb Field

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By using electrostatic hexapole field, "steric effect" in chemical reactions has been extensively studied.[1)] This method enables us to control reactant molecular orientation prior to collision. Intensity of oriented molecular beam, however, inevitably becomes weaker than its un-oriented molecular beam by more than one order of magnitude due to the hexapole-selection. This is the most disadvantageous point when we wish to use oriented molecular beam. This project aims at resolving this weak point by developing a sophisticated method so-called "Electrostatic Honeycomb Field" for intensifying oriented molecular beam. Basic idea of the method is that a beam intensity is simply proportional to the number of beam lines and they can be focused on a point in space after the hexapole state-selection.

Figure 1 (top) shows photo views of the newly developed honeycomb electric field. The electric field consists of 24 pieces of electrodes which form seven sets of hexapole electric field lines. The seven beam lines are pointing at a point in downstream. Figure 1 (bottom) shows the schematic illustration of the apparatus. Seven sets of pulse valves (1 mmϕ), beam skimmer (1 mmϕ), and beam collimator (5 mmϕ) followed by the honeycomb field (1 m long), are mounted on four pieces of supporting stainless rods (15 mmϕ). All beam lines focus on to a point in the 1 m forward distance from the honeycomb filed. The honeycomb electrode is made from carbon fiber (CFPR pipe, 15 mmϕ, 7.5 mmϕ, 1 m long). Carbon fiber is chosen because of its light weight and high electric conduction. Polyacetal insulator is used as the electrode supporter. Beam intensity is monitored by a quadrupole mass spectrometer. As a preliminary experiment, we made comparison of the beam intensity between single-beam run and seven-beam run, and we obtained the expected beam enhancement. Additionally, we have obtained the focusing effect for acetonitrile molecule (CH_3CN, μ = 3.92 D) by use of honeycomb electric field for the first time. We are now doing to optimize the operating in order to get the most intensisve oriented molecular beam.

Reference

1) "*Steric Effects in Small Radical Formations*," in The *Chemical Dynamics and Kinetics of Small Radicals, Part II*, K. Liu and A. Wagner, Eds., Advanced Series in Physical Chemistry (World Scientific), K. Kuwata, and T. Kasai, Vol. **6**, 842-935 (1995)

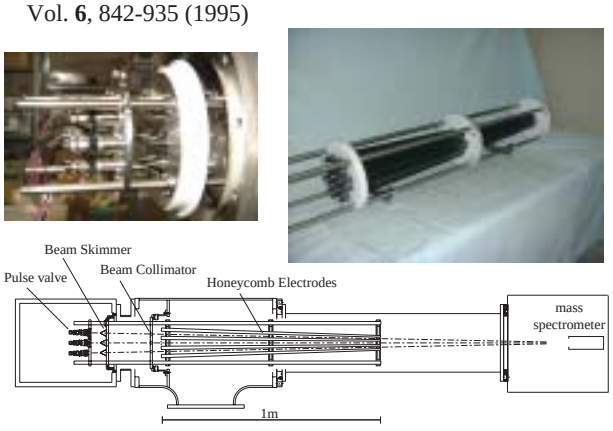

Figure 1. Honeycomb type orientational state selector. The beam source and the honeycomb electric field (top) and a schematic view of the newly designed apparatus for intense oriented molecular beam (bottom).