Figure 4. Reaction scheme "B" for synthesis of oligomer of DMA.
TASK 4: SO₂ SCRUBBING WITH HOLLOW FIBER CONTACTORS

The objective of this task is to determine the fundamental mass transfer characteristics of hollow fiber contactors (HFCs) for scrubbing SO₂ from a simulated flue gas. These devices have been shown to be capable of removing more than 99% of the SO₂ from a simulated flue gas. However, the principles of mass transfer in HFCs are not established on a sound basis, especially for a system with a liquid phase chemical reaction.

Under subcontract to SRI, Dr. K. Sirkar at the New Jersey Institute of Technology (NJIT) will be responsible for Task 4. In this task, we intend to gather a series of steady state mass transport data under various conditions. We will systematically vary the gas flow rate, the liquid flow rate, the liquid composition, and the HFC module properties such as the length and diameter of the hollow fibers and the fiber packing fraction of the module. We will perform our experiments both at room and 70°C. This work will be done with small modules in cylindrical form so as to achieve a well defined flow distribution in the module. Along with the mass transport rate data, we will compile gas-side and liquid-side pressure drop data.

The main accomplishments in this quarter were establishing the NJIT subcontract and reaching an agreement with Hoechst/Celanese (HC) on exactly what modules we will test in the first two years of the project. NJIT has full authority to proceed with Task 4 and is preparing its experimental apparatus.

The modules that we believe make sense for the first two years of the project and that HC agreed to supply will have a "cross flow" geometry and contain enough fibers so that feed gas flows can be kept below 10 liters/min (a practical laboratory upper limit) and that we can achieve a wide range of SO₂ and NOₓ scrubbing efficiencies. The term "cross flow" refers to the fact that the feed gas will flow at 90° to the scrubbing liquor in the module. This geometry will be the geometry of the large scale modules that HC will be commercializing in the next few years. Therefore, our lab results should be scalable.

To understand the flow geometry of the HC module, it helps to understand how the module is made. First, the hollow fibers (300 micron O.D. Celgard fibers) are woven with a netting made of very narrow polyester fibers (about 10 microns diameter; Figure 5). This netting comes on a roll like a roll of carpet. The roll is typically 36" long (along axis of roll; this length is the length of the hollow Celgard fibers). Transverse to the axis, there are 50 Celgard fibers per inch. To make
Figure 5. Structure of Celgard Fiber Netting.

The support fibers are interwoven transverse to the Celgard hollow fibers.
a module, HC starts with a porous central tube. Netting is wrapped around this central tube continually, adding layer upon layer until the netting reaches a suitable thickness (e.g., 4 inches, Figure 6). This module roll is glued and cut to a desired length (presently 11" and 27" are HC preferred lengths). The ends of the module are potted with epoxy and cut, and end caps are attached. In a finished module, a liquid passes into the central tube and then flows radially outward over the hollow fibers. The gas is passed down the lumen of each fiber (Figure 7).

The modules HC makes for us can have any length and contain any number of fibers. The diameter of the epoxy plug can be keep the same from module to module (e.g. 2"). We can ask for as little as 157 fibers (one wrapping around a standard 1" O.D. central tube). What we asked for was four types of modules consisting of two fibers lengths (12" and 6") and two numbers of fibers (200 and 1000). HC agreed to supply the 12" modules by 11/30/92 and the 6" modules in the "first quarter" of 1993. This schedule will delay our progress somewhat on Task 4 but will not delay our progress on any other task. Dr. Sirkar has in his possession a trial cross flow module from previous work with HC and will be able to start his work now with that module.
Figure 6. Wrapping of netting around central tube.
Figure 7. Flow pattern of gas and liquid in "cross flow" module.
The fluid passed into the central tube flows radially across the hollow fibers.