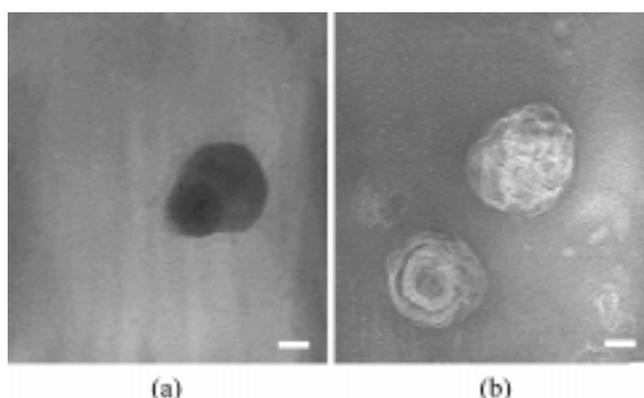


**Figure 2.** FT-IR spectra of (a) before and (c) after acidic hydrolysis.

procedure was repeated three times. According to the FT-IR spectra, the absorption peaks of amide groups at about 3400 and 1654  $\text{cm}^{-1}$  in Figure 2a disappeared, and instead the peaks of carboxyl groups at about 3500-2400 and 1706  $\text{cm}^{-1}$  in Figure 2b emerged clearly. This result indicates that the hydrophilic head groups were removed from the skeletonized vesicle surface.

The modified vesicles were visualized by transmission electron microscopy (TEM, JEOL-JEM 1200EX microscope) after staining with uranyl acetate solution. Most of the hydrolyzed vesicles retained their original spherical shapes, but a so-called parachute-like morphology was also occasionally observed, as shown in Figure 3a. Jung and coworkers observed the parachute-like structures from the polymerization of styrene in dioctadecyldimethylammonium bromide vesicles.<sup>6,7</sup> They claimed that the structures resulted from complete phase separation between the styrene polymer and the vesicle-bilayer matrix. A similar argument can be applied here in explaining the morphology of the skeletonized vesicles. Namely, polymerization of DVB proceeds in the bilayer latex-like fashion almost independently from BDAC. Preferential sorption of DVB to the DVB polymer occurs due to the higher solubility of DVB in its growing polymer than in the polymerizing BDAC bilayer, resulting in development of a new environment where the DVB polymers are growing until DVB is depleted. If the new environment formed in the non-polymerizable (DPPC) domains, the DVB polymer would be possibly released in the form of freely floating latex beads during the skeletonization.

We actually skeletonized the vesicles composed of DPPC and BDAC after polymerization. They were not parachute-like, but approximately spherical shaped, as shown in Figure 3b. The vesicle surface appears to be undulated. The surface morphology may form during the sample preparation, and/or may be also due to the cross-linked polymer within the bilayer because the polymer forces the aggregates to adopt



**Figure 3.** TEM micrographs: (a) after chemical modification of skeletonized vesicles prepared from BDAC, DPPC and DVB, (b) before chemical modification of skeletonized vesicles prepared from BDAC and DPPC only. The scale bar corresponds to 20 nm.

geometries which are ideal with respect to the polymer conformation rather than the minimization of the surface between water and the surfactant.<sup>4</sup> However, the acidic hydrolysis disrupted the vesicles, and most of the new aggregates could not be identified. This result suggests that DVB was copolymerized with BDAC in the bilayers composed of BDAC, DPPC, and DVB, and the cross-linked hybrid vesicles could retain their original shapes even after the hydrolysis.

In conclusion, vesicles composed of BDAC, DPPC, and DVB were polymerized and skeletonized. Finally, the hydrophilic head groups of BDAC components in the polymerized membrane were successfully removed by acidic hydrolysis to obtain porous vesicles with surface covered by carboxyl groups. The surface morphology of the resulting vesicles will be reported in the near future.

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