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Practical Methods for Transmission Electron Microscopy of Polymers.

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Morphological characterization of polymers and polymer blends by transmission electron microscopy (TEM) is complicated by the low intrinsic level of available contrast. This tutorial will cover practical methods for TEM contrast enhancement of polymer microstructures, including ultramicrotomy and staining. Both ultramicrotomy and staining techniques are commonly used in biological sciences as well as in polymer science. Almost all methods of contrast enhancement of polymer materials using ultramicrotomy and staining are derived of the methods used in biological sciences where they are widely spread and commonly used on a routine base. In polymer science the situation is different due to the wide variety of polymer materials currently available and the continuous development of new polymer materials. Ultramicrotomy and staining methods can be straightforward for materials like impact-modified polystyrenes and acrylonitril-butadiene-styrene copolymers (Fig.1) when room temperature ultramicrotomy can be used in combination with osmium tetraoxide (OsO_4) staining [1]. Contrast enhancement of polymers becomes more complicated when room temperature ultramicrotomy isn't possible and cryoultramicrotomy is needed, to obtain high quality ultra thin sections of polymers for TEM, state of the art advanced instruments are a must. [2] The choice of the right temperature settings depends of the physical properties of the material or of one of the components present in a polymer blend or composite. Ruthenium tetraoxide (RuO_4) [3,4,5,6,7] is nowadays a commonly used contrast enhancement method to characterize the morphology of semi-crystalline polymers (Fig.2) and polymer blends. The advantages of the differences in interaction of ruthenium tetraoxide with different polymers are well known, but at the same time it can make contrast enhancement of polymers a complex matter. Double staining [5] of polymer blends using a combination of osmium tetraoxide (OsO_4) and ruthenium tetraoxide (RuO_4) can be a solution to solve part of these problems. (Fig. 3,4)

The practice of these contrast enhancement methods using ultramicrotomy and staining will be discussed, including sectioning artifacts [8], various methods of contrast enhancement, the relative advantages and disadvantages of block staining as opposed to the staining of ultra thin sections, and staining artifacts; and problem solving strategies. Finally a view on the future of ultramicrotomy will be given [9].

Technical details and practical tips will be covered.

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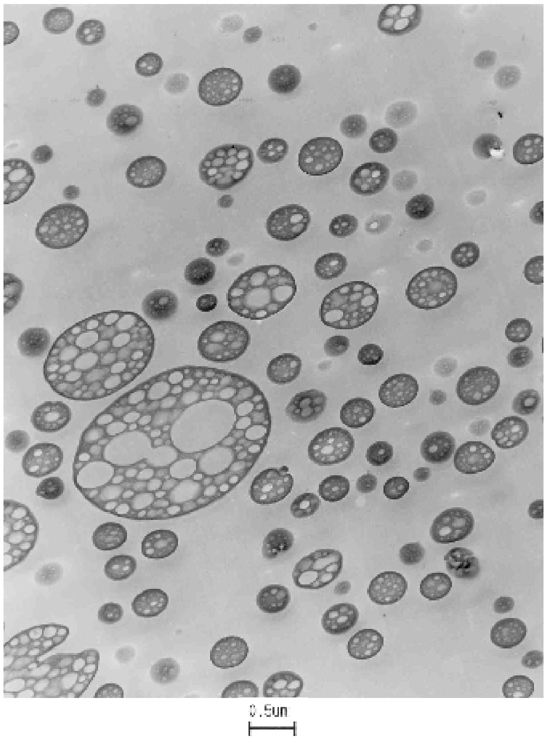

Fig.1. OsO_4 stained ABS copolymer.

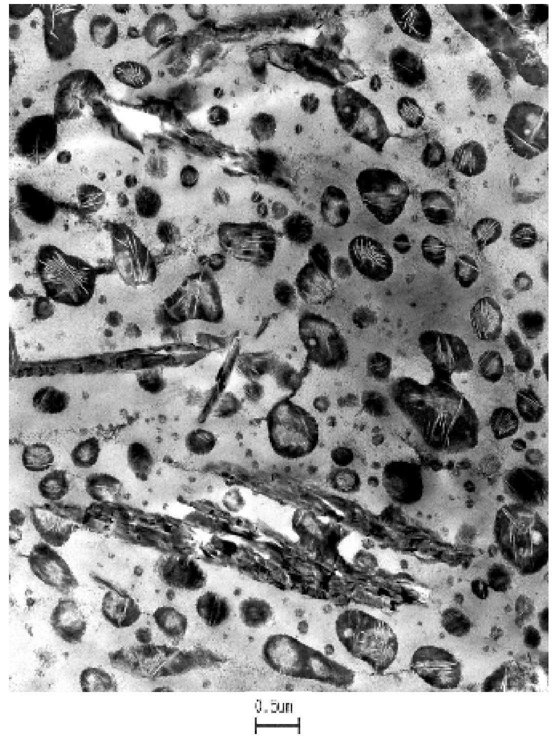

Fig. 2. RuO_4 stained impact modified Polypropylene.

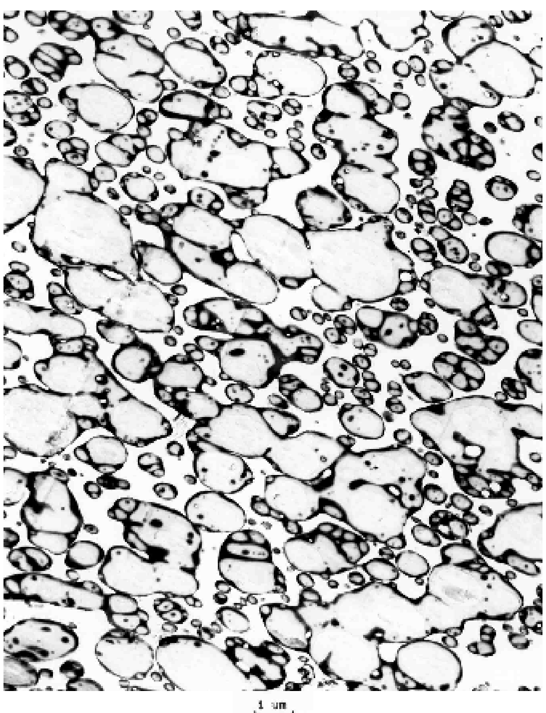

Fig. 3. RuO_4 stained POM / ABS / TPU blend.

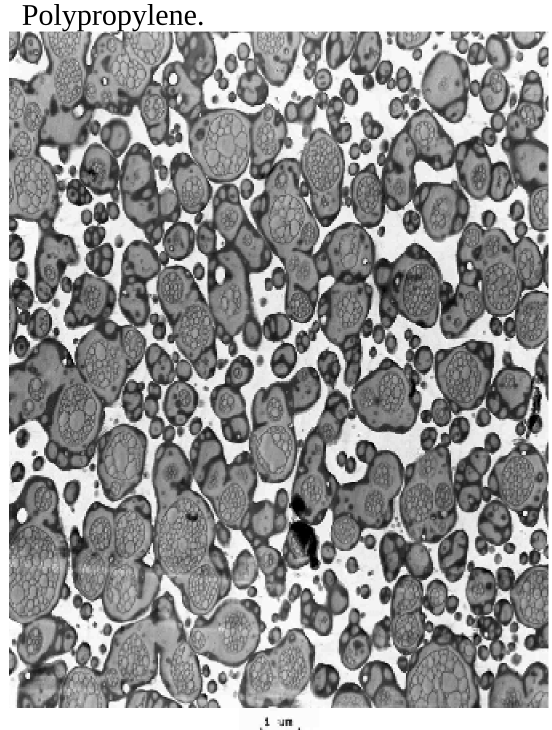

Fig. 4. OsO_4 + RuO_4 stained POM / ABS / TPU blend.

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