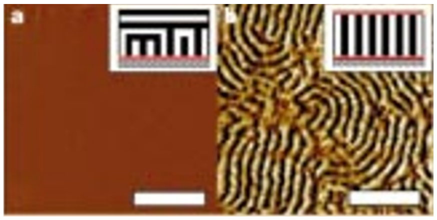

Figure 1 Atomic force microscopic phase images. Images are from thin films of a P(S-b-MMA) symmetric diblock copolymer with a random copolymer (red) anchored either: a, to the substrate only; or b, to the substrate and air surface. Scale bar, 1 μm. Insets indicate the orientation of the lamellar morphology in the films.

a different morphology, such as cylinders. Our approach of controlling interfacial interactions allows a wide variety of nanoscopic structures to be produced, which potentially have applications as diverse as membrane separation[7], quantum electronics[8], nanolithography[9] and catalysis[10].

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How to store seeds to conserve biodiversity

Zheng *et al.*[1] pointed out the potential advantages of 'ultra-dry' (less than 5% moisture content) seed storage for the long-term genetic conservation of plants, based largely on their studies of seed vigour. Here we support their suggestion, using our data from several years ago which showed that ultra-dried seeds have increased survival periods[2].

It has been shown that seeds of many species can benefit from being cooled and dried. Their longevity over a range of conditions can be described by an improved seed viability equation[3], although there are limits to the range of conditions over which this equation applies. For long-term seed storage, it is the lower temperature and moisture-content limits that are of most concern. The lower temperature limit is probably about −20 °C (ref. 3), although experiments at high temperatures (necessary to reduce longevity at low moisture contents to only a year or so) show that the low moisture-content limit is that produced by equilibrating seed at 10–12% relative humidity at 20 °C before storage[4]. It is this protocol, combined with storage at ambient or cooler temperatures, that has been described as 'ultra-dry' seed storage[5].

Although practical tests have indicated the benefits of ultra-dry storage[6,7], some controversy remains. It has been reported that ultra-dry storage may adversely affect seed vigour at certain temperatures[8], although other results have not identified this problem[9].

The results of Zheng *et al.*[1] support the practical application of ultra-dry seed storage as a low-cost, simple technology for gene banks. However, we question their suggestion[1] that this treatment provides longevity equal to that of more conventional gene banks. In some species at least, ultra-dry seed storage at ambient temperatures results in more rapid loss of seed viability than storage at about 5% moisture content at − 18 °C (ref. 6).

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Refrigeration can save seeds economically

Seed genebanks around the world are seeking economical ways to store seeds as a means of conserving plant biodiversity. Zheng *et al.*[1] suggest that the use of 'ultra-dry' technology[2,3], in which the seeds are dried to a water content of less than 5%, can extend the longevity of some seed species sufficiently to reduce or eliminate the need for refrigeration. This would benefit in particular some developing countries, such as China, for which they say the cost of cold storage is prohibitive.

It is widely accepted that drying seeds can increase their longevity[3–5], and there is general agreement that, moisture contents being equal, the same seed lot will survive longer if stored at lower temperatures[3–5]. The salient issue is whether the longevity achievable with various preservation protocols is sufficient for the conservation of germ plasm.

Base collections need seeds to survive for decades[3]. Zheng *et al.*[1] report good survival of ultra-dry *Eucommia* seeds after two years of storage at ambient temperatures. However, ultra-dry technology has several technical problems, including: (1) a general decline in germination within five years; (2) a narrow range of allowable moisture contents for seeds stored at high temperatures; and (3) a tremendous variability in longevity among different seed cultivars[5].

Relatively successful storage has been reported for ultra-dry seeds of a single rape-seed cultivar in which 100% and 42% of seeds germinated after 11 and 18 years, respectively, but this is not representative of the performance of *Brassica* species under ultra-dry storage conditions[5]. Our germination records (www.ars-grin.gov/nssl; data available on request) show that refrigerated storage is required to achieve the seed longevities required for *ex situ* germplasm conservation.

Ultra-dry technology might seem to be economical, but this does not take into account the high cost of establishing the optimum water content for individual seed accessions or the labour-intensive expense of frequent viability monitoring and regenerations. Added to this is the risk of losing valuable germ plasm when seeds die during storage or accessions are regenerated from small populations. When these factors are considered, refrigeration, by comparison, is a bargain.

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