

Fig. 3. Schematic drawing of the fibril as a helicoidal structure with folded chains.

ly exceeds the platelet thickness, it seems reasonable to conclude that the fibril platelets are composed of folded chains (Fig. 3).

The phenomenon of the growth of fibrillar crystals with folded chains, as described, has been observed in all six of the polymers studied. It therefore seems to be a general feature of heterogeneous Ziegler-Natta catalysis. It is noteworthy, however, that it apparently does not occur in homogeneous catalysis. For example, a polyethylene sample prepared with the soluble catalyst—dicyclopentadienyl-titanium dichloride—dimethyl aluminum chloride (4)—consisted of the conventional lamellar single crystals.

The significance of these findings may extend beyond their morphological interest. Indeed, the growth of long whisker-like crystals during polymerization with heterogeneous catalysts must be intimately related to the physicochemical processes taking place at the catalyst surface.

The nature of these processes is not fully understood. It is convenient to consider the development of structure in these systems in two stages, namely, the growth of fibrils and their organization into hollow sacs. Experiments by Rodriguez and Gabant (5) suggest that the active sites of an $\alpha\text{-TiCl}_3\text{-Al}(\text{CH}_3)_3$ catalyst are localized along growth spirals on the catalyst surface. Traces of polymer appearing as dots along the spirals have approximately the same width as our fibrils.

It is thus reasonable to suppose that the fibrils are formed by the crystallization of polymer chains growing out from the active sites. We envisage that one end of the fibril is anchored on the catalyst surface and the process can therefore be likened to root growth in whiskers. Many conceptually possible mechanisms of the globulation have been considered, but they all have shortcomings. It should be emphasized that, while the formation of

globules can be suppressed by proper choice of experimental conditions, the observed fibril growth occurred under all conditions in these polymerizations and may therefore be considered as basic to the mechanism of Ziegler-Natta catalysis.

In many stereospecific polymerizations, crystallization takes place with remarkable facility as compared to normal solution crystallization. Whereas isotactic polystyrene will not crystallize from solution in xylene or toluene in any reasonable time (up to several months), it does so virtually simultaneously with polymerization as indicated above. Other polymers show similar behavior. This may indicate that a heterogeneous catalyst, in addition to exerting a strong influence on the

stereoregularity of the polymer, also serves as a "nucleator" by governing the conformation of the polymer as it leaves the surface.

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Dormancy Regulation in Peach Seeds

Abstract. *An inhibitor of seed germination was isolated from the integuments of Lovell peach seeds. Evidence from chromatographic analysis, from studies of its absorption of ultraviolet light and from assays on its effects on plant growth, indicate that the inhibitor is, if not identical with, dormin. Termination of rest in peach seeds is correlated with the disappearance of the inhibitor. The effects of the inhibitor are antagonistic to those of gibberellic acid on sections of wheat coleoptiles.*

Studies of growth inhibitors in seeds may be useful in determining the mechanisms controlling rest in hardy plants. In such studies, it is necessary to identify the compounds responsible for inhibition of germination and to correlate their concentrations in the seed with the termination of rest. We now report the isolation of an inhibitor from peach seed integuments, its probable identification, and its relation to rest in peach seeds.

Peach seeds are dormant at the time of fruit harvest and normally require stratification at 2° to 5°C under moist conditions for 10 to 12 weeks to bring about the resumption of growth (1). However, removal of the integuments results in immediate germination of nonstratified seeds (2). The seedlings which develop from these seeds are either dwarfed or normal, depending on the germination temperature (3). Vegis (4), and Wareing *et al.* (5) have reviewed the literature on dormancy in higher plants; considerable reference was made to the complex termed " β -inhibitor" (6) as the possible regulator of dormancy.

Intact peach seeds (200 g) were extracted in four changes of 200 ml each

of distilled water at 0°C for 7 days. The aqueous extracts were combined, acidified to pH 2 to 3 with HCl and extracted in 400 ml of anhydrous diethyl ether. The ethereal fraction was partitioned into acidic and neutral fractions by methods essentially similar to those described by Kefford (7). The acidic fraction contained a substance which inhibited both the elongation of sections of wheat coleoptiles and the germination of wheat and peach seeds. It had a relative flow rate (R_F) value characteristic of the β -inhibitor (6). The inhibitor was located mainly in the outer and inner integuments of the seed and was distributed equally throughout them. Its action was expressed at the micropylar end of the seed where it inhibited radicle elongation, which is the first phase of embryo growth in germination.

The inhibitor is acidic in nature; soluble in water, ether, ethanol, methanol, acetone, and aqueous solutions of Na_2CO_3 ; and was stable at 100°C for at least 10 to 15 minutes. The gross characteristics of the peach seed inhibitor were essentially the same as those described for the β -inhibitor (6).

The acidic fraction and numerous

standards were cochromatographed bidirectionally, first in a mixture of isopropanol, ammonium hydroxide, water (10:1:1, by volume) and then in one of isopropanol and water (80:20, by volume). We observed the developed chromatograms under ultraviolet light of long and short wavelength before and after spraying them with several chromogenic reagents. The properties of the inhibitor were in all respects similar to those of the compound dormin (8).

The inhibitor was eluted with ethanol from several chromatograms. The ultraviolet absorption spectra of the eluant in acidic and basic ethanol were compared with and found to be very similar to those of dormin (Fig. 1) and to those previously reported for dormin (8).

Dormin and the peach seed extract were chromatographed simultaneously in six different solvent systems. In all cases, the R_f of the inhibitor in the seed extract was similar to that of dormin (Fig. 2).

Applications of dormin (10 ppm) and peach seed extract (6.4 g of seeds per milliliter of extract) to the leaves of actively growing 8-week-old Lovell peach seedlings caused them to assume certain features characteristic of plants approaching winter rest. Internode elongation was inhibited, and the plants developed rosettes. Some leaves formed absciss layers; anthocyanin developed in the stems which thickened in their apical regions.

Data from assays of chromatographically fractionated peach seed extracts on coleoptiles of wheat made at 2-week

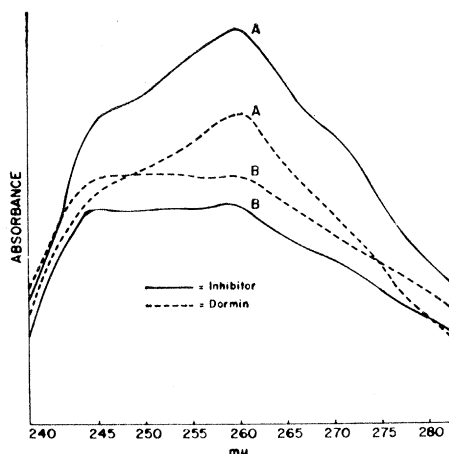


Fig. 1. Ultraviolet absorption spectra of dormin and the inhibitor extracted from peach seeds. Each was measured in acidic (A) and basic (B) ethanol.

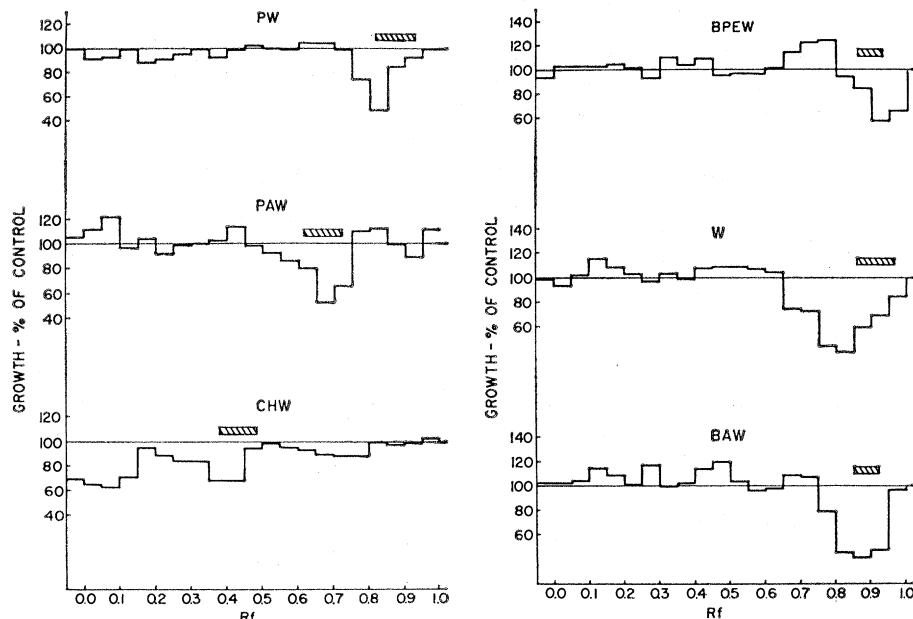


Fig. 2. Wheat coleoptile assays of Lovell peach seed extracts chromatographed in PW (isopropanol and water, 80:20 by volume), PAW (isopropanol, ammonium hydroxide, and water, 10:1:1 by volume), CHW (chloroform, hexane, and water, 15:75:10 by volume), BPEW (1-butanol, 1-pentanol, ethanol, and water, 1:1:2½:4 by volume), W (water), and BAW (butanol, acetic acid, and water, 4:5:1 by volume). The cross-hatched inserts represent the location of dormin on chromatograms developed in the same solvent systems. $t_{0.01}S_x = 11$ percent.

intervals during the period of seed stratification indicate that the inhibitor zone at R_f 0.65 to 0.75 disappeared by the 6th week of stratification. The disappearance of the inhibitor was correlated with the ability of the seeds to germinate after they were removed from stratification and placed on moist filter paper at 20°C. After as many as 12 weeks of stratification, however, seeds with intact integuments germinated more slowly than those without integuments; for 6 to 8 weeks, their seedlings were relatively stunted compared to seedlings from excised embryos. Seedlings produced from excised embryos were induced to behave as those from seeds with integuments by application of peach seed extract (equivalent to 2.3 g of seeds per milliliter of extract) or dormin (10 ppm) to the embryo or subsequent seedling. These results suggest that physiological dwarfing in peach seedlings is caused by a certain concentration of the inhibitor, which, nevertheless, is not high enough to prevent germination of the seed.

The inhibitor and dormin were also tested in combination with GA₃ (gibberellic acid) and IAA (indole-3-acetic acid) in wheat coleoptile section tests. Both were antagonistic to GA₃ and both partially reversed the growth induced by IAA.

Our results indicate that inhibition of germination of peach seeds is due to a substance similar to dormin which disappears or is inactivated during stratification of the seeds.

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