Table III. Relative Energies (Electronvolts) for $XSiH_3 \rightarrow XSiH_2^- + H^+$ [a]

X	6-31++G(d,p) SCF	6-31++G(d,p) MP2	6-31++G(d,p) MP4	MC-311++G-(3df,2pd) SCF	MC-311++G-(3df,2pd) MP2	ΔH [b]
CH_3	16.97	16.85	16.83	17.06	16.78	16.50
NH_2	17.02	16.85	16.82	17.15	16.84	16.56
OH (tent)	16.87	16.71	16.68	17.05	16.76	16.47
OH (plow)	16.88	16.70	16.68	17.05	16.75	16.47
F	16.59	16.48	16.45	16.74	16.48	16.21
SiH_3	16.19	16.04	16.04	16.25	15.90	15.70
PH_2	16.22	16.14	16.15	16.31	16.04	15.75
SH (tent)	16.13	16.12	16.11	16.28	16.06	15.77
SH (plow)	16.12	16.10	16.09	16.26	16.03	15.74
Cl	16.02	16.05	16.03	16.21	16.03	15.73

[a] At the 6-31G(d) geometries. [b] Corrected for zero-point vibrational energies, scaled by 0.89.

and F increase the acidity. The effects of the substituents *relative to each other* are similar to those found here, except that the effect of NH_2 and CH_3 are reversed.

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Synthesis of Aldose Sugars from Half-Protected Dialdehydes Using Rabbit Muscle Aldolase[1]

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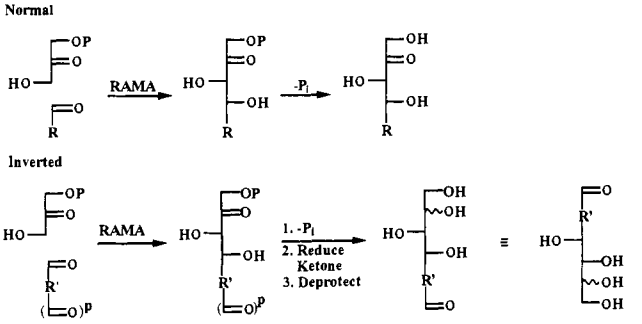
Rabbit muscle aldolase (RAMA) is a useful catalyst for the synthesis of sugars.[5,6] The "normal" application of this enzyme in synthesis is to catalyze the aldol condensation of dihydroxyacetone phosphate (DHAP) and an aldehyde with formation of a carbon–carbon bond having the D-threo configuration (Scheme I).[5]

Scheme I. Strategies for Using RAMA To Synthesize Ketoses and Aldoses[a]



[a] The designation $(=O)^P$ refers to a protected aldehyde group.

RAMA has three useful characteristics as a catalyst for aldol condensations: When RAMA is used, the hydroxyl groups present in the reactants need not be protected. It accepts a wide variety of aldehydes.[6] Its reactions are stereospecific. It also has limitations: It requires DHAP as one substrate, and it generates only vicinal diols having D-threo stereochemistry at C3–C4.[6] It also does not produce aldoses: Its products necessarily have a ketone group at C2 rather than an aldehyde group at C1. Conversion of a ketose to an aldose is not straightforward.[7]

Here we describe a new strategy for using RAMA (the "inverted" strategy, Scheme I) that increases the usefulness of this enzyme as a catalyst in the synthesis of sugars. We also demonstrate the value of L-iditol dehydrogenase (IDH) as a catalyst for the diastereospecific reduction of the ketone in this class of carbohydrates to an alcohol.[8,9]

RAMA-catalyzed aldol condensation between DHAP and a half-protected dialdehyde, $OCHR'(CHO)^P$, generates a protected aldose having a ketone (that derived from DHAP) at C_{n-1}. Dephosphorylation, reduction, or other transformation of the ketone and deprotection of the aldehyde provide the aldose. Both the structure of this aldose and the location of the vicinal diol formed in the aldol reaction can be controlled through the structure of R'. The ketone group derived from the DHAP offers control of the chemistry at the end of the sugar distal to the aldehyde. Scheme II illustrates this "inverted" approach to the synthesis of sugars using RAMA with syntheses of L-xylose (**4**) and 2-deoxy-D-*arabino*-hexose (**9**).

RAMA-catalyzed (50 units) condensation of diethoxyacetaldehyde (**1**)[10] (1 mmol, added in five portions over 5 days) and D-fructose 1,6-diphosphate (1 mmol) in the presence of triosephosphate isomerase (EC 5.3.1.1, ca. 200 units), followed by treatment in situ with acid phosphatase (AP, 20 units), afforded **2** in 60% overall yield.[11] Conversion of ketone **2** (1 mmol) to alcohol **3** with L stereochemistry was accomplished in 69% yield, using IDH (from *Candida utilis*, 10 units),[9] coupled with formate dehydrogenase (FDH, 10 units) and sodium formate (3 mmol)

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(11) Compounds **2–4** and **6–9** were purified by flash chromatography on silica gel (10–20% CH_3OH/CH_2Cl_2). NMR analysis indicates that they are greater than 95% pure.

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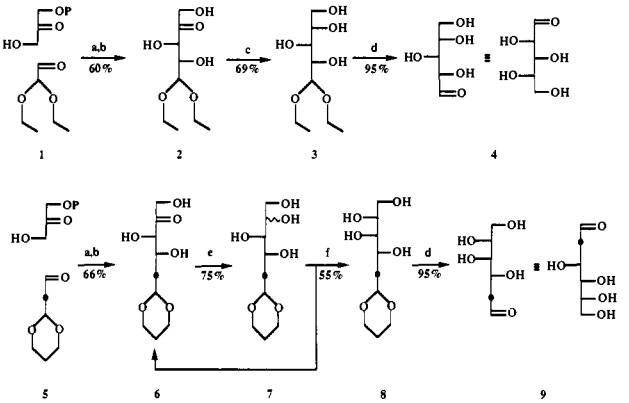
Scheme II. Synthesis of L-Xylose (**4**) and 2-Deoxy-D-*arabino*-hexose (**9**)[a]



[a] (a) RAMA (EC 4.1.2.13); (b) AP (EC 3.1.3.2); (c) IDH (EC 1.1.1.14, from *Candida utilis*)/NADH/FDH (EC 1.2.1.2)/formate; (d) aqueous HCl/THF; (e) $NaHB(OAc)_3$/HOAc; (f) IDH (EC 1,1.1.14 from sheep liver/NAD^+/GluDH (EC 1.4.1.3)/KG/NH_4^+.

to recycle NADH (0.017 mmol).[12] Hydrolysis of the acetal with aqueous HCl (0.5 M)/THF (1:1) yielded **4** (95%), which was indistinguishable by ^{13}C and ^1H NMR (500 MHz) spectroscopy from the commercially available enantiomer D-xylose.

To generate the opposite (D) stereochemistry on reduction of the ketone required an additional step (Scheme II). Ketone **6** was obtained in 66% yield by RAMA-catalyzed (250 units) reaction of 1,3-dioxane-2-acetaldehyde (**5**)[13] (3.8 mmol) and DHAP[14] (3.5 mmol) followed by dephosphorylation with AP (200 units). Compound **6** (2 mmol) was reduced with $NaHB(OAc)_3$ (5 mmol)[15] in acetic acid. This reduction yielded a mixture of the desired (5*R*) and undesired (5*S*) diastereomers in a 2:1 ratio (NMR analysis) and 75% yield. The 5*S* diastereomer was removed by treating the mixture of diastereomers **7** (0.9 mmol) with IDH (13 units)[8] and NAD^+ (0.005 mmol),[16] using an L-glutamic dehydrogenase (GluDH, 48 units)/2-ketoglutarate (KG, 0.3 mmol), ammonium sulfate (0.3 mmol) cofactor recycling system.[12] The product of oxidation, **6** (15%), could, in principle, have been recycled to increase the yield of **8** but was, instead, discarded. Compound **8** was isolated in 55% yield (from **7**). Deprotection of the aldehyde **8** with aqueous 1.0 M HCl/THF (1:1) yielded 2-deoxy-D-*arabino*-hexose (**9**, 95%), which was indistinguishable from authentic material by ^{13}C and ^1H NMR (500 MHz) spectroscopy.

These two procedures demonstrate that RAMA accepts the half-protected aldehydes **1** and **5** as substrates and illustrate the application of this observation in syntheses of aldoses. These syntheses also show the value of IDH, or of $NaHB(OAc)_3$ in combination with IDH, in generating alcohols of either stereochemistry from the ketones derived from DHAP.

We are now addressing the most important remaining limitation of aldolase-catalyzed synthesis—the restriction of the D-threo stereochemistry for the vicinal diol—by exploring aldolases having stereochemical preferences different from RAMA.[6]

Supplementary Material Available: Experimental details for the synthesis of compounds **2–9** (5 pages). Ordering information is given on any current masthead page.

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1,2,3,5-Diselenadiazolyls as Building Blocks for Molecular Metals. Preparation and Structures of $[PhCN_2Se_2]^+PF_6^-$ and $[PhCN_2Se_2]_2$

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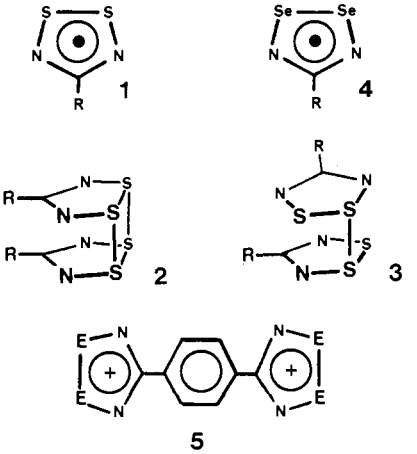
The search for neutral, low-dimensional conducting materials[2] has kindled interest in the preparation and study of heterocyclic thiazyl radicals;[3,4] recent attention has been focused on 1,2,3,5-dithiadiazolyls **1**.[5] These planar seven-π-electron radicals are known to associate in the solid state in one of two modes, i.e., **2** (R = Ph)[5e] and **3** (R = CF_3,[5d] NMe_2,[5a] Me[6]). To date, however, there is no evidence of the desired packing mode, i.e., vertical stacks of uniformly spaced radicals.[7] In order to test the effect on interdimer interactions of the replacement of sulfur by selenium, we have prepared and structurally characterized the hitherto unknown 1,2,3,5-diselenadiazolyl **4** (R = Ph).



1,2,3,5-Dithiadiazolium salts are accessible by a variety of routes.[3,5d,8] We have found, however, that the reaction of the

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