On the Stereochemistry of E'- and E"-Reactions[†]

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The decarboxylative E'-dehydration of B,Y-unsaturated &-hydroxy acids with DMF-dineopentylacetal shows SYN-faciality irrespective of whether the conformation of the hydroxy group relative to the double bond axis is anticlinal or synclinal.

We wish to summarize in this paper experimental results of a stereochemical study carried out in the period of 1974-1981, 1-3) results that had been the subject of numerous lectures, but have remained unpublished so far. The study was an (unsuccessful) attempt at illustrating experimentally a correlation between the steric course (SYN, ANTI) of allylic reactions (E', SE', SN') and the conformation of their allylic reacting groups. Such a conformational correlation may suggest itself if one analyzes the problem of the stereochemistry of allylic reactions within the conceptual framework of the τ -bond model⁴⁾ of the carbon-carbon double bond. Within the popular σ, π -bonding model, any qualitative analysis of that problem requires specific consideration of the structural effects of σ, π -mixing.⁵⁾ Therefore, the τ -bond model which - so to say - makes use of "single bonds" only, may incorporate the information required for such an analysis even at the most qualitative (graphical) level. The intrinsic equivalence of the two models, often quoted to justify preponderant use of one and neglect of the other, is an aspect that refers to the models at the level of their quantum mechanical expression and not necessarily to their drastically dismantled versions used by experimental organic chemists.

Scheme 1.





The τ -bond model describes a (concerted) E_2 '-process as a (concerted) succession of two E_2 -reactions, and SE_2 '- and SN_2 '-processes as combinations of an E_2 -process with an SE_2 - and SN_2 -reaction respectively. Allylic conjugation in transition states of allylic reactions may be treated as σ, σ -conjugation expected to follow the principle of maximal interaction in antiperiplanar arrangements of the reacting

 $^{^{}m \dagger}$ Dedicated to Teruaki Mukaiyama on the occasion of his 60th birthday.

bonds. Interpreting allylic reactions and the faciality of reactions at double bonds in general within the τ -bond model invites the extrapolative use of both the concepts and the wealth of empirical knowledge referring to the nowaday well recognized effects of $(n \rightarrow \sigma^*)$ - and $(\sigma \rightarrow \sigma^*)$ - conjugation, such as the anomeric effect and, more specifically, its σ , σ -analogue which is believed to result in what is known as the gauche effect.⁶⁾ Furthermore, the model points to a dichotomy in the conformational relationship of a reacting allylic bond with its conjugating τ -bond (see Scheme 1). This dichotomy is analogous to the one presented by antiperiplanarity versus synperiplanarity of reacting bonds in E₂-reactions. In as far as the popular view of allylic groups to react in orthogonal conformations is representative of what the σ/π -model at the level of its general use (de facto a " π -only" model) predicts, the dichotomy of anti- versus syn-clinality of reacting allylic groups is a specific asset of the τ -model; experimental support for the existence of such a dichotomy would be of considerable interest for the stereochemistry of allylic reactions and even more so for our assessment of the merits of the two qualitative multiple bond models. Schemes 2 and 3 summarize experiments which were aiming at providing such support in specific examples of E'-reactions.

The study is based on our earlier finding⁸⁾ that β,γ -unsaturated δ -hydroxycarboxylic acids dehydrate smoothly with concomitant decarboxylation under very mild conditions on treatment with DMF-dineopentylacetal. The central step in the preparation of diastereomeric reactants is the highly diastereoselective Hg(II) or (better) Pd(II)-catalyzed⁹⁾ signatropic ($\alpha \approx \gamma$)-equilibration of β -acetoxy-methylesters (e.g. $\underline{1} \approx \underline{3}$ and $\underline{1a} \approx \underline{3a}$). Assignment of the relative configuration in the reactants (e.g. $\underline{4}$ and $\underline{4a}$) rests on this rearrangement to occur suprafacially and (as experimentally established for $\underline{2}$ and $\underline{2a}$, see Scheme 2) γ, δ -unsaturated β -hydroxycarboxylic acids to dehydrate decarboxylatively with the DMF-acetal in the ANTI-mode.¹⁰

The Newman projections of the reactants 5 and 5a (Scheme 3) illustrate the expectation of SYN-E'-stereochemistry based on the concept of maximal conjugation (antiperiplanar arrangement) of reacting bonds with τ -bonds in a conformationally fully staggered system.¹¹⁾ Reactant <u>6</u> (X-ray analysis¹³⁾) cannot follow the same pattern since its hydroxy group has no choice than to be synclinal to the double bond axis (synperiplanar to adjacent τ -bond). This would make ANTI the expected E'-mode for <u>6</u> and <u>6a</u>; the same holds for <u>7</u> and <u>7a</u>.¹⁴⁾ Experimentally, all three pairs of reactants¹⁵⁾ show SYN-Elimination!

Could the SYN-faciality of the conformationally unconstrained reactants 5 and 5a result from a reaction path that (in contrast to expectation) preferred both reacting groups to be synclinal instead of anticlinal relative to the double bond axis? If this were the case, also 6 and 7 would be unconstrained models and would be free to eliminate SYN, as they do. Reactant 8 (X-ray analysis¹⁶) should then, however, be expected to eliminate ANTI, since its hydroxy group cannot but assume the anticlinal conformation. Experimentally, 8 and 8a eliminate SYN!

E"-reactions have been predicted by σ/π -mixing arguments⁵⁾ to occur ANTI, and the same is expected from τ -model considerations for conformationally unconstrained



systems. The hydroxy acids 9 (X-ray analysis¹⁷⁾) and 9a (Scheme 4) react with DMFdineopentylacetal (-20 $^{\circ}C \Rightarrow 20 \,^{\circ}C$) without stereoselection to give the same mixture of EEE- and EEZ-octatrienes (48:52). Presuming that this result reflects the formation of a (flat) carbenium intermediate, and taking heed of the principle that higher electron density favors pyramidality of reaction centers and the preservation of stereochemical information, the anionoid E"- and E'-reactions depicted in Scheme 4 were tested. They were found to proceed indeed with high diastereoselectivity, but all of them SYN. Specifically, the expected SYN \rightarrow ANTI-alternation between the E'and E"-process¹⁸) was not observed.

Are the "predictions" referred to above artefacts of the (graphical) τ -bond model, or was - in retrospect - the choice of the two E'-reaction models a particularly unfortunate one? (Syn-orientation of oppositely charged or Li-chelated leaving groups overwhelming stereoelectronic factors in the transition state?)²⁰⁾

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