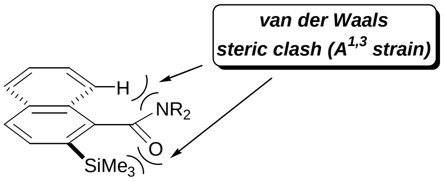
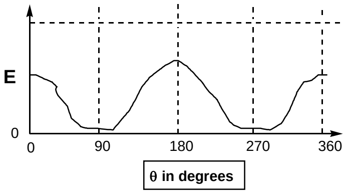
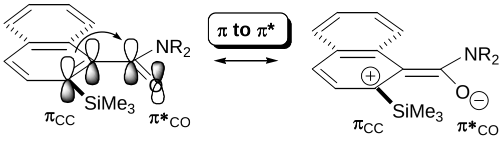
2ND YEAR ORGANIC PROBLEM CLASSES 2003/2004
Class 2. Dr Alan Spivey – Stereoelectronics – Answers
Class to be held at *3pm on Monday 17th November 2003* in normal tutors groups

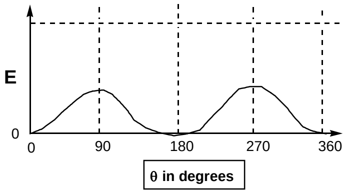
1 (a) (i) Two major factors: ***steric***: favouring perpendicular orientation of groups so as to avoid severe A^{1,3} strain between *ortho*-substituents ($\theta = 90^o, 270^o$).





stereoelectronic: favouring co-planar arrangement of π-systems for maximum overlap ($\theta = 0^o, 180^o$).

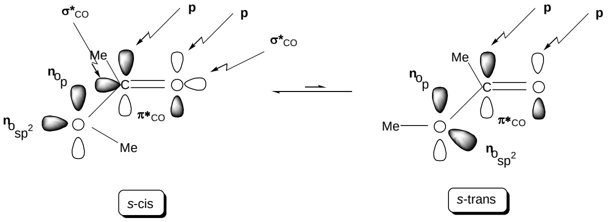




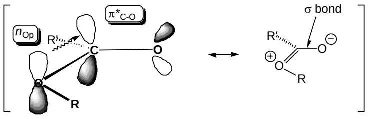
- Overall energy profile is a superposition of the two profiles.
- 'global' minimum is at ~ 45% which is a compromise between the two effects (i.e. reasonable overlap of orbitals but not excessive steric clash).
- 'global' maximum dominated by harsh steric clash when co-planar ($\theta = 180^o$) N(^{i}Pr)$_2$ is "passing" *peri*-naphthaldene hydrogen.

(ii) The two structures at θ = 90° and θ = 270° are enantiomers.

(b) For the ***ESTER***:

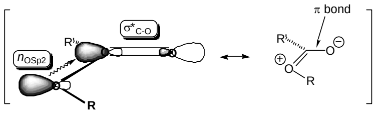


Carboxylic esters prefer to adopt conformations in which all the atoms of the functional group are in a common plane. These planar conformations are stabilised by n_{Op}->π^*_{C-O} 'resonance'. There are two such planar conformations: *s*-cis and *s*-trans. Because the p-orbital on oxygen is symmetrical resonance does not favour either relative to the other.

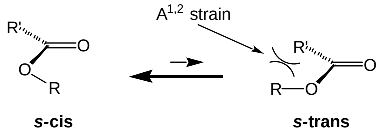


However, there are three factors which make the *s*-cis more stable:

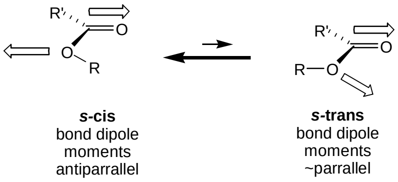
- Firstly, there is a n_{Osp2}->σ^*_{C-O} anomeric effect which stabilises the *s*-cis form.



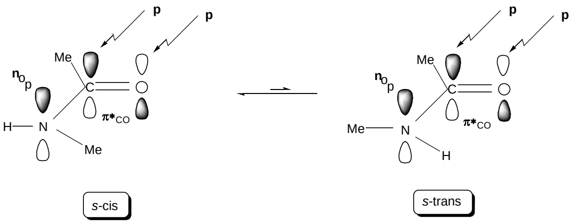
- Secondly, there is significant $A^{1,2}$ strain in the *s*-trans form (the sp^2 hybrid lone pairs on the carbonyl oxygen are 'small' relative to any substituent bonded to the acyl carbon atom).



- Thirdly, the *s*-cis form has a significantly smaller overall dipole moment relative to the *s*-trans form. There is a general preference for conformers with minimum overall dipole (minimum overall charge separation).

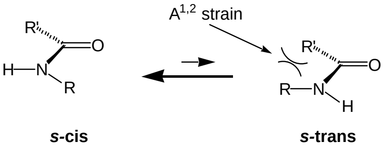


For the ***AMIDE***:



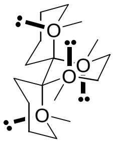
Carboxylic amides, like esters, prefer to adopt conformations in which all the atoms of the functional group are in a common plane due to resonance. The $n_{Np}\text{->}\pi^*_{C\text{-}O}$ interaction in amides is stronger than the corresponding $n_{Op}\text{->}\pi^*_{C\text{-}O}$ interaction in esters because the nitrogen lone pair is a better donor than the oxygen lone pair. This is manifested in the high barrier to rotation about the acyl nitrogen bond. Amides, like esters, prefer to adopt *s*-cis conformations but that enthalpic difference in ground state energy is less pronounced ($\Delta H° \sim 10 kJmol^{-1}$, *cf.* $\sim 25 kJmol^{-1}$ for esters). The reason for this is that there is no sp^2 lone pair on the nitrogen available for anomeric interaction with the carbonyl σ* orbital (or making a significant dipole). This means that the only factor favouring the *s*-cis conformation over the *s*-trans is:

- $A^{1,2}$ Strain in the *s*-trans form:



(c) (i) Compound (**2**)

(ii) The dispiroketal forms as a single diastereomer as the result of its formation being under *thermodynamic control*. The product observed is stabilised by four anomeic effects ($\mathbf{n}_O \rightarrow \boldsymbol{\sigma}_{CO}$).



*****