



FIG. 3 Schematic potential energy profiles for the reactions $O + HCN$ and $Cl + HCN$. The high energy of the $CICN$ product (and even higher energies of CCI and NCl , not shown) limit the possible outcomes of $H-CICN$ complex formation.

plex, however, seem to prohibit the alternative reaction: the barrier to forming $H + CICN$ would appear to be larger than the total available energy (Fig. 3). Thus for Cl atom attack at the CN the complex can only decompose back to reactants or form $HCl + CN$ — the same products formed in the direct reaction. The formation of this complex means that the $C-N$ bond is no longer a spectator but rather a full participant, receiving its share of the available energy in the reaction.

These measurements demonstrate both the simplicity and the subtlety of vibrational state control of chemical reactions. Even exciting a well isolated vibration does not guarantee successful control: although the $H-CN$ bond is still cleaved in this reaction, one sees from these results that, in general, attack at other bonds will compete with the desired reaction path. One needs the right excitation and the right chemistry for vibrational state control to be successful.

The limitations of vibrational state control should in no way be viewed as discouraging. These detailed measurements are providing portions of the complete map of state-to-state quantum transition amplitudes: starting in a particular initial quantum state, what is the probability of ending up in a particular final quantum state? Detailed theoretical simulations of these reactions can provide insight into the intimate details of the dynamics of the complex, and refine our understanding of the potential energy surfaces on which the reaction takes place⁵⁻⁷. Given complete knowledge of the potential energy surface and the state-to-state dynamics, one can contemplate augmenting vibrational state control with other techniques to achieve selectivity of chemical products. A macroscopic analogy might be the control of an automobile (where inelastic collisions and undesired fragments are to be avoided also). Vibrationally unselected reactions follow no planned route. Vibrational state

control sets a well defined route which, once initiated, cannot be changed. The control of the future can be compared to automated driving, in which a computer maps many routes and instantaneously adjusts the vehicle direction and speed depending on traffic conditions (and police surveillance).

One good way forward might be to combine vibrational state control with oriented molecules⁸⁻¹¹. The relative orientation of reactants strongly affects which products are formed; indeed, in all the $X + HCN$ reactions, it is probably the angle of attack that determines whether direct abstraction or complex formation occurs. Relative orientation is probably the single most important feature not controlled in the vibrational-state-controlled experiments. In addition, one might aim to prepare more complicated vibrational excitations, including coherent 'superposition' states, which lead selectively to the desired chemical product. Such states have been proposed for selective bond breaking in unimolecular reactions¹²⁻¹⁵. Technically, this is much more difficult for bimolecular reactions: it would essentially involve synchronization of vibrational preparation and collision on a femtosecond timescale.

Despite the practical difficulties that lie ahead, there is widespread optimism that control of bimolecular reactions will become a reality. In the same way that microwaves are replacing (or at least supplementing) conventional ovens, it is not difficult to imagine that fifty years from now the present paradigms for doing chemistry — mixing substances in solution together and heating — will seem primitive and quaint. □

David J. Tannor is in the Department of Chemistry and Biochemistry, University of Notre Dame, Indiana 46556, USA.

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Virtual assembly

THE current elections for the European Parliament fill Daedalus with gloom. Parliaments, he points out, no longer decide anything. These days they are simply devices for judging the emotional ascendancy of the competing parties, like the screaming matches conducted between rival tribes of monkeys. The European Parliament cannot even carry out this function. Multiple translation obscures the mood of the assembly. It just reflects the deeper absurdity of trying to unite nations that speak many different languages.

Modern technology, says Daedalus, can do much better. Years ago he proposed a 'virtual committee' whose members did not meet, but typed their remarks into a common computer system which distributed them to all the screens. Cunningly, all contributions were anonymous. Leaders could not enforce their opinions, and underlings could not simply support their own side. All were forced to consider the proposals on their merits. The changing mood of the virtual committee was monitored by frequent polling and voting. Systems like this are now in experimental operation. Any number of people can 'talk' at once, so shy geniuses cannot be shouted down by forceful blusterers. All comments stay on the record, visible to all parties; minutes are kept automatically.

Clearly this is the way forward for the European Parliament. The expensive buildings in Strasbourg and Brussels should be sold, the endless travelling eliminated, and the whole thing conducted on the Internet. Machine translation could provide rough drafts of each comment in every official language; human translators would tidy these up and release them onto the Net.

A totally new political process should result. The traditional tribal warfare, the dishonest rhetoric and tedious oratory, would be replaced by thoughtful written arguments. Unsocial parliamentary hours would cease. Debates would run continuously and in parallel. Each member could log off at any time, and return later to scan the accumulated discussion, add his own comments and vote on current resolutions. He could consult expert witnesses elsewhere on the Net. The flood of facts and arguments might even make him change his mind! The 'Delphi' technique of repeated voting, with all voters seeing the results instantly, leads to rapid consensus: sound, well argued policies should emerge at a great pace. To foil impersonators, and to free the members from having to play to a gallery of electronic eavesdroppers, the debate should be encrypted. David Jones