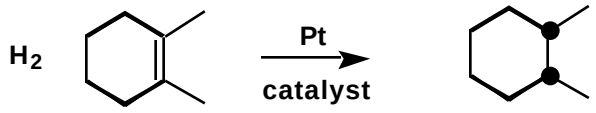
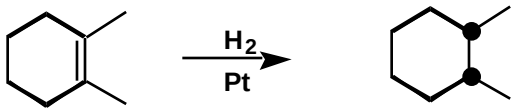
Text Related to Segment 12.02 ©2002 Claude E. Wintner

We have noted that, in the presence of molecular hydrogen and platinum catalyst, two hydrogen atoms are added *to the same face* of the double bond in 1,2-dimethylcyclohexene, to yield *cis*-1,2-dimethylcyclohexane, with a *balanced, stoichiometric equation* as follows. The facial specificity of the reaction is readily apparent from the *cis* stereochemistry of the product:



balanced equation

There are several other forms of writing any organic reaction, each useful in its place. If we are interested in the reaction as a *synthetic* one — as a recipe, so to speak — then frequently we use the form:

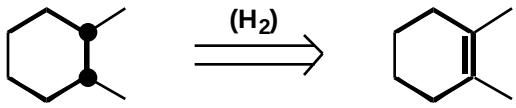


synthetic form

by which we mean, "If you take 1,2-dimethylcyclohexene, and mix it with molecular hydrogen in the presence of platinum catalyst, you can expect to get *cis*-1,2-dimethylcyclohexane."

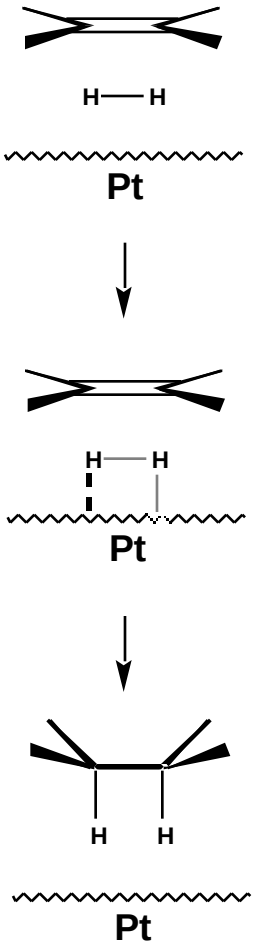
Alternatively, we may consider the reaction in *retrosynthetic* form. For any pathway by which one approaches a target molecule, of necessity there must be a concluding transformation in the synthesis. A number of possibilities may exist for such a final step. However, the present analysis is simplified by the fact that at this stage of our discussion we have at our disposal only a single reaction, rather than the larger arsenal that might be at hand, and therefore would have to be evaluated.

Thus, thinking now only in terms of the reaction we know, in our retrosynthesis we imagine *dissecting*, rather than constructing, the target, exactly reversing our thought process for the reaction in the forward direction. In this manner we work *backwards* to our reactants, which, in the forward reaction, ought to lead to the target. Note that our fragments will be simpler than the target molecule. This concept of a retrosynthetic analysis, seemingly so trivial in this simplest of examples, really does demand a new point of view, and it becomes an extraordinarily powerful tool when applied to complex, multistep syntheses, as we shall see.



retrosynthetic form

Finally, there is the question of the *mechanism* of the reaction — *How* does it occur? Both the catalytic effect of the platinum and the observed *cis* stereochemical course of the reaction come about as a consequence of the fact that molecular hydrogen is adsorbed on the platinum surface, with the result that the H—H bond is weakened, in turn making it possible for the exothermic reaction to occur (a beneficial trade of the H—H σ bond and the C—C π bond in exchange for two C—H σ bonds). Delivery of the two atoms of hydrogen must take place from the platinum surface, and hence to a single face of the π bond:



schematic for mechanism of Pt catalyzed addition of molecular hydrogen to a double bond

In sum, all four of these forms of writing chemical reactions — balanced, synthetic, retrosynthetic, and mechanistic — can be useful when we consider any organic chemical transformation. Each focuses us on a different aspect of the whole, and we shall have frequent recourse to them all. Thus, it is important that the differing formulations, as well as the distinct concepts which they represent, be kept properly separated in our minds.