

Article-Based Questions

Directions: Read the article "Built for speed" and then answer these questions:

- 1. Pick out your favorite metaphor used by the author to describe a catalyst. Use it to explain the purpose of a catalyst in a chemical reaction.
- 2. Liming Dai and other scientists are engineering new materials that have a catalytic power similar to platinum. Why is there a need for new catalytic materials?
- 3. Carbon might be an alternative to platinum and other precious metals used as catalysts. Chemist Huixin He notes that carbon structures alone aren't catalytically active. What alterations are made to carbon structures so that they can serve as catalysts?
- 4. Huixin He's team is working with phytic acid as an alternative catalytic material. How are the researchers transforming phytic acid into a catalyst and what are the advantages of using it?
- 5. Explain the advantages and disadvantages of using enzymes as catalysts for industrial purposes.
- 6. Rather than finding alternatives to catalytic metals, chemist Younan Xia is researching ways to minimize platinum waste. What structures are Xia and his team developing and why are they effective catalytically?
- 7. Briefly explain why "Built for speed" is a fitting title for this article.



Responses to Article-Based Observation

- 1. Pick out your favorite metaphor used by the author to describe a catalyst. Use it to explain the purpose of a catalyst in a chemical reaction. Possible student response: The author describes a catalyst as a "molecular matchmaker." During a chemical reaction, molecular bonds are broken and new bonds are formed between different atoms. Catalysts help increase the rate of a reaction by bringing reactant atoms or molecules together, which changes the reaction pathway. Though they help lower the activation energy needed to start the reaction, catalysts aren't chemically altered or used up during the reaction.
- 2. Liming Dai and other scientists are engineering new materials that have a catalytic power similar to platinum. Why is there a need for new catalytic materials? Possible student response: Platinum and other precious metals are often used as catalysts in clean energy technologies. Developing cheaper, more abundant and sustainable substitutes for these metal catalysts could allow clean energy technologies to compete with fossil fuels.
- 3. Carbon might be an alternative to platinum and other precious metals used as catalysts. Chemist Huixin He notes that carbon structures alone aren't catalytically active. What alterations are made to carbon structures so that they can serve as catalysts? Possible student response: One carbon structure that researchers are working with is graphene, a chicken wire-like sheet of carbon atoms bonded in hexagonal rings. Rolled up sheets of graphene, known as carbon nanotubes, have also been used as the base of carbon catalysts. To make graphene or the nanotubes catalytically active, researchers have also been replacing some of the carbon atoms in the ring with nitrogen or other atoms. The specific application for these catalysts will determine the type of atom impurity and the carbon structure needed.
- 4. Huixin He's team is working with phytic acid as an alternative catalytic material. How are the researchers transforming phytic acid into a catalyst and what are the advantages of using it? Possible student response: Phytic acid is a substance composed of carbon, oxygen and phosphorus. He's team is microwaving liquid phytic acid to form a sooty black powder. The energy of the microwaves heats up and rearranges the atoms to form an amorphous structure of carbon and phosphorus atoms. The main advantage of this phytic acid-derived catalyst is that it is very easy to make. It has sped up reactions that produce fuel from hard-to-use molecular reactants found in plant cellulose.

- 5. Explain the advantages and disadvantages of using enzymes as catalysts for industrial purposes. Possible student response: Inside living things, enzymes assist with everything from copying genetic information to processing nutrients. Enzymes are specific to a reaction and don't expend much energy catalyzing unwanted side reactions. Another advantage is that they can be easily altered for a particular set of reactants. A disadvantage is that they are often too fragile to use in industrial manufacturing.
- 6. Rather than finding alternatives to catalytic metals, chemist Younan Xia is researching ways to minimize platinum waste. What structures are Xia and his team developing and why are they effective catalytically? Possible student response: Xia and his team are developing platinum "nano-cages." To create the nanocages, palladium cubes are coated with a thin layer of platinum. The palladium inside is chemically removed, leaving a hollow platinum skeleton. Since only the top layer of a catalyst interacts with the reactants, the structure maximizes the surface area of the platinum to reduce the amount of unused platinum.
- 7. Briefly explain why "Built for speed" is a fitting title for this article. Possible student response: Scientists are using many different methodologies to build the most effective, cost-efficient catalysts possible. Catalysts allow important industrial reactions, such as the reactions in a fuel cell, to occur at a much faster rate.