d-Block transition metal catalysis in organic synthesis for a sustainable and prosperous world in the 21st century and beyond

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Despite worrisome decrease in birth rate in many advanced nations, the world population has been and will almost certainly be increasing. Needless to say, more foods, clothing, fuels, and many other items consisting largely of organic substances will be needed.

In the past, these items had been mostly obtained from natural resources through farming, forestry, fishing, mining and so on. In view of various growing difficulties including that mentioned above, some fundamentally innovative solutions would undoubtedly be needed. And, this author firmly believes that it would be critically needed for us, mankind, to learn how to recycle chemically, as well as biologically or biochemically, CO_2 and H_2O. Needless to say, such processes should be practically useful by virtue of being catalytic, economical, safe, and so on. This indeed should be considered as one of the most important challenges of the 21st century for chemists. Even though these does not appear to be any satisfactory solution as of today, we must nevertheless consider it to be feasible on the basis of what we know today.

Looking back, F. Haber (1918 Nobel Chemistry Prize) discovered a high temperature-pressure and yet practical synthesis of ammonia contributing immensely for solving food shortage problems of a century ago, and it has continued to be critically useful even today. Turning our attention to clothings, essentially all of the clothing items as of a century ago including cotton, wool, and silk were made of natural high polymers prepared naturally and biologically. When Japan controlled exporting silk to America, a man-made fiber, nylon, was chemically invented and industically produced from coal, petroleum, and so on. Aside from delicate issues, such as "feel" etc., nylon has ably substituted and even surpassed silk. Very importantly, this marked only the beginning of a series of chemical inventions and developments, including those of polyesters (tetoron, etc.), polyacrylonitrile, polyethylene, polypropylene, and so on.

These discoveries and developments powerfully and eloquently support our notion and proposal of how the magical power of chemistry can save and enrich our society. Furthermore, it is one of this author's notions that many related significant and basic chemical findings, such as those by H. Staudinger (1953 Nobel Chemistry Prize), K. Ziegler and G. Natta (1963 Novel Chemistry Prizes), will continue serving as fundamentally useful guides in our future investigations.

In recent years, a rather superficial "misconception" saying that "organic synthesis without the use of metals are greener than those using metals." All other things being equal or nearly comparable, use of H, for example, rather metals may well be greener. However, all other things are seldom or almost never the same or ever comparable. We must not overlook various roles of metals(M), such as (1) formation of metal salts as a thermodynamic sink, (2) serving regio- and stereomarkers for high, often ~ 100%, selectivities, and (3) provision of relatively facile entry into all important catalytic processes, just to mention a few.

As well known, many inexpensive metals, such as Na, Mg, Zn, B, Al, Si, Ti, Mn, Fe, Cu, etc., serve as foundations of various major industries. Provided that they can be recycled, they are indeed used both stoichiometrically and catalytically.

It is this author's firm view that one crucial key to discovering and developing "green" chemical synthesis is to discover and develop many organic synthetic reations that are high Yielding(Y), of high Efficiency(E), of high Selectivity(S), Economical(E), and Safe(S), namely organic syntheses of $Y(ES)^2$, through the use of $24 - 1(=23)$ *d*-block transition metals as superior catalyst components.

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