マイクロ波効果の理論的考察

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Theoretical Studies on Microwave effect

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The wavelength of microwaves is long enough compared to the molecular or lattice distance. Therefore, when microwaves are applied to a substance composed of particles of the order of Avogadro's number, the electrons in the substance undergo a dielectric polarization "Uniform motion" in which the phases are aligned. This property is the essential difference between thermal photons such as infrared and microwave processes. The dielectric polarization given to this structure excites electrostatic sound waves, that is, acoustic phonons. This electrostatic acoustic phonon converges on "thermal motion" through "various relaxation processes" (1) . It is assumed that there is a probability that electrostatic acoustic phonons and thermal phonons will overlap during this convergence, resulting in phonons with large momentum. The analogy is "phonon growl". If this "groan" exceeds the order of intermolecular binding force, rapid chemical reactions and phase transitions that cannot be obtained by thermal equilibrium occur. When the probability of this groan is sufficiently large compared to the probability of convergence to thermal motion (relaxation time to heat), a chemical reaction or phase change occurs without the intervention of thermal motion. I would like to present this as the mechanism of the non-thermal effect of microwaves. Phenomena that occur in such a non-equilibrium state have not been dealt with by chemical thermodynamics. However, it will be a crucial process for the development of low-temperature, low-carbon processes that the world is competing with.

Keywords : Microwave; Ordered motion; Relaxation to thermal motion

マイクロ波の波長は、分子あるいは格子距離に較べて十分に長い。このため、マイクロ波が、アボガドロ数オーダーの粒子から成り立つ物質に照射されたとき、物質中の電子に位相が揃った誘電分極「同期(Uniform)運動」を起こす。この性質が、赤外線などの熱フォトンとマイクロ波プロセスの本質的な違いである。この構造に与えられた誘電分極が静電音波、即ち、音響フォノンを励起する。この静電音響フォノンは「様々な緩和過程」を経て、「熱運動」に収斂して行く(1)。この収斂の間に、静電音響フォノンと熱フォノンが重なり、運動量の大きなフォノンが生じる確率があると仮定する。アナロジーとしは「フォノンの唸り」である。もし、この「唸り」が、分子間の結合力のオーダーを越えると、熱平衡では得られない迅速な化学反応や相転移がおきる。この唸りの確率が、熱運動に収斂する確率(熱への緩和時間)に較べて、十分に大きいとき、熱運動を介さずに化学反応や相変化が起きる。これが、マイクロ波の非熱的効果の機構であると提示したい。このような非平衡状態で生じる現象は、化学熱力学では取り扱えってこなかった。しかし、世界がしのぎを削っている低温・低炭素プロセス開発には、決定的に重要なプロセスとなる。

1) S. Takayama, M. Sato, and J. Fukusima, " Microwave Engineering of Materials", Pan Stanford Publishing Pte. Ltd. (2015), P32～72.

