MICROWAVE ASSISTED SYNTHESIS, CROSSLINKING, AND PROCESSING OF POLYMERIC MATERIALS

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ABSTRACT

Microwave technology has been developed primary for communication and some areas of processing such as cooking food, thawing, and curing wood and rubber. As a heat source, microwaves allow a sample to be irradiated instantly with an associated rapid heating rate. Moreover, microwaves offer a number of advantages over conventional heating such as non-contact heating (reduction of overheating of material surfaces), energy transfer instead of heat transfer (penetrative radiation), material selective and volumetric heating, fast start-up and stopping and reverse thermal effect, i.e. heat starts from the interior of material body.

In the last decade, microwaves have attracted the attention of chemists who have begun to apply this unconventional technique as a routine in their practice. The reduced time of processing under microwave conditions found for a great number of chemical reactions was the main reason that microwave techniques become so attractive for chemists. The result and advantages of microwave processing of material can be increase of productivity, improved product characteristics, uniform processing, less manufacturing space required, and controllability of the process. Microwave processing seems to be easily scaled up from a small batch process to a continuous process employing a conveyor. Besides ceramic, polymer processing forms probably the largest single discipline in microwave technology, and the methods and procedures used therein are certainly seen among the most developed. The purpose of this report is to provide some details concerning the application of microwave irradiation to polymer chemistry and technology. A survey of the past achievements in polymer synthesis can be found together with discussion of the free-radical polymerization, polyaddition as well as polycondensation reactions, crosslinking and processing of polymeric materials with the stress on chemistry of those

processes. A short description of the nature of microwaves as well as their interactions with different matter, in particular with organic substances, will be given [1].

I can be shown that polymer synthesis as well as processing can greatly benefit from the unique featured offered by modern microwave technology, which was demonstrated in many successful laboratory-scale applications. These can include such technical issues as shorter processing time, increased process yield, and temperature uniformity during polymerization and crosslinking. Although, microwave energy is more expensive than electrical energy due to the low conversion efficiency from electrical energy (50% for 2.45 GHz and 85% for 915 MHz), efficiency of microwave heating is often much higher than conventional heating and overcomes the cost of the energy.

Not all materials are suitable for microwave applications, and a special characteristic of every process has to be matched. Therefore, a real cross-disciplinary approach has to be considered to fully understand all the limitation and advantages of microwave processing. Improper application of microwave irradiation will usually lead to disappointments, while proper understanding and use of microwave power can bring greater benefits than it can be expected. For example, three typical temperature-time stages in can be observed during polymerization reactions. First, initial temperature rise by direct heating of monomer(s) where the temperature rose slowly. Second, a significant temperature peak with maximum temperature due to the exothermic reaction. Third, free convective cooling to an ambient temperature indicating an end to the exothermic reaction processes. Fast exothermic reaction heating usually accelerates the temperature rise and gradient inside the samples. Neither continuous microwave nor thermal processing can be effectively controlled in order to maintain constant temperature/time profile through the entire process. However, pulsed microwave heating can be used to control temperature and eliminate the exothermic temperature peak, maintain the same temperature at the end of reaction [2].

Furthermore, fundamental differences in the heat transfer during material processing in thermal and microwave fields is that microwave energy, in contrast to thermal heating, is supplied directly to a large volume, thus avoiding the thermal lags associated with conduction and/or convection. Consequently, temperature gradients and the excessive heat build-up during thermal processing could be reduced by a microwave power control. Thus, a comparison of thermal and microwave processing assumes a new dimension when the temperature distribution inside the sample is considered, and that is where the scientific challenge lies [3].

The action of microwave irradiation on chemical reactions is still under debate, and some research groups have mentioned the existence of so-called non-thermal microwave effect, i.e. inadequate to the observed reaction temperatures sudden acceleration of reaction rates [4]. Regardless of the type of activation (thermal) or kind of microwave effects (non-thermal), microwave energy has its won advantages which are still waiting to be fully understood and applied for chemical process.

References

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