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PIEZOELECTRIC EFFECT AND ITS USE IN MEDICINE

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Abstract: The piezoelectric effect is a phenomenon where certain materials generate an electric charge in response to applied mechanical stress. This effect has found various applications in the field of medicine, including medical imaging, drug delivery, and tissue engineering. This article explores the principles of the piezoelectric effect and its use in medicine, highlighting its potential to revolutionize healthcare technology.

Keywords: piezoelectric effect, medical imaging, drug delivery, tissue engineering, healthcare technology

The piezoelectric effect was first discovered by Pierre and Jacques Curie in 1880 when they observed that certain crystals such as quartz produced an electric charge when subjected to mechanical pressure. Since then, this phenomenon has been extensively studied and applied in various technological fields. In medicine, the piezoelectric effect has emerged as a promising tool for advancing diagnostic and therapeutic approaches. This article will delve into the fundamentals of the piezoelectric effect and its diverse applications in modern medicine.Smart piezoelectric materials are of great interest to us due to their properties. Piezoelectric materials can convert mechanical energy into electrical energy and vice versa. The forms of piezoelectric materials include mono and polycrystals (piezoceramics), polymers and composites. In recent years, advances have been made in the use of piezoelectric materials in biomedical devices due to their biocompatibility and biodegradability. Medical devices such as actuators and sensors, energy harvesting devices, and active scaffolds due to neural tissue engineering are constantly being explored. Actuators with piezoelectric material sensors can change flow rate, pressure, etc. to produce or consume energy. This article covers the use of smart materials in the design of medical devices and provides more information about the piezoelectric effect in the medical industry today. A series of concepts related to piezoelectricity should be understood in relation to future development and industrial challenges.

The piezoelectric effect is a fascinating phenomenon that has found numerous applications in various fields, including medicine. This effect refers to the ability of certain materials to generate an electric charge in response to applied mechanical stress. In other words, when these materials are subjected to pressure or deformation, they produce an electric voltage.

In medicine, the piezoelectric effect has been leveraged for a range of purposes, from diagnostic imaging to drug delivery and tissue engineering. One of the most well-known applications of this effect is in ultrasound technology. Ultrasound machines use piezoelectric crystals to generate high-frequency sound waves that can penetrate the body and create detailed images of internal organs and tissues. When an electrical current is applied to these crystals, they vibrate and emit sound waves, and when the sound waves bounce off internal structures and return to the transducer, they create a picture of the area being examined.

Another important use of the piezoelectric effect in medicine is in the development of piezoelectric sensors for monitoring bodily functions. These sensors can be used to measure parameters such as blood pressure, heart rate, respiratory rate, and even muscle activity. By

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converting mechanical signals into electrical signals, these sensors provide valuable information for diagnosing and monitoring various medical conditions.

Furthermore, researchers have been exploring the use of piezoelectric materials for targeted drug delivery. By incorporating these materials into drug delivery systems, it is possible to trigger the release of medication in response to specific mechanical stimuli within the body. This approach could potentially improve the precision and efficacy of drug delivery while minimizing side effects.

In addition to diagnostic imaging and drug delivery, piezoelectric materials are also being investigated for their potential role in tissue engineering and regenerative medicine. These materials have shown promise in stimulating cell growth and differentiation through the application of mechanical forces, offering new possibilities for repairing damaged tissues or organs.

Various molecules, microorganisms or biological structures can be detected using piezoelectric biosensors. Piezoelectric biosensors are made from materials with acoustic velocities, for example, a highly sensitive and selective sensor for ethionamide controlled by molecular modeling, aluminum nitride (AlN) acoustic biosensors that provide real-time response and quantitative data, and for pesticide residue detection highly sensitive AlN biosensor. Piezoceramic sensors exhibit good repeatability, good linear response and low detection limit. AlN piezoelectric biosensors can be used to monitor several specific biological reactions, for example, genetic hybridization, which can provide information about reaction kinetics. Another early application of AlN sensors is the detection of protein-ligand interactions or antigen-antibody binding.

Overall, the piezoelectric effect has opened up new frontiers in medical technology and treatment methods. Its ability to convert mechanical energy into electrical signals has revolutionized diagnostic imaging with ultrasound technology and holds great potential for improving drug delivery systems and tissue engineering techniques. As research in this field continues to advance, it is likely that we will see even more innovative applications of the piezoelectric effect in medicine in the future.

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