

核材料与粒子辐射效应

聚四氟乙烯密封材料的电子束辐射效应研究

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摘要

采用低能电子束辐射系统地研究了操作氚系统用密封材料(聚四氟乙烯)的辐射效应。利用扫描电镜和X光电子能谱仪分析了材料的表观形貌和表面元素的变化, 用X射线粉末衍射仪和热分析仪分析了辐照前后材料的结晶度改变和热稳定性程度, 并利用气相色谱仪和质谱仪测定了辐射降解气体的成分和生成量随吸收剂量的变化规律。采用电子自旋共振谱仪研究了材料在辐照过程中产生的中间体(自由基), 利用正电子湮没寿命谱仪分析了材料中的自由体积孔洞及浓度。结果表明, 辐照前聚四氟乙烯样品的表面是规则的带状晶形结构, 经 1×10^5 Gy辐照后样品的晶状结构遭到了明显的破坏, 向非晶态转变显著。辐照后样品的熔点和热分解温度均呈下降趋势, 表明样品的热稳定性降低。聚四氟乙烯材料在氧气气氛中发生的辐射降解最为严重, 其次是真空, 而在氚气气氛中辐射降解最少。材料的辐射降解主要发生在主链上, 即C—C键断裂, 而侧基C—F键的断裂相对较少。第三寿命强度I₃的变化规律与τ₃相反, 即随吸收剂量的增大, 第三寿命的强度I₃降低, 表明自由体积孔洞的浓度降低。

The radiation effect of polytetrafluoroethylene used as a kind of sealing material in the tritium system was studied by using electron beam. The superficial configuration and state were analyzed by SEM and XPS respectively, and the crystal degree and thermal stability were determined by XRD and DSC. At the same time the composition of gas products after radiation, was measured by GC/MS, and the yield of CO₂ with the dose increasing was analyzed. The free radicals produced in the process of radiation were studied by ESR, and the content of free volume of PTFE is analyzed by positron annihilation lifetime spectroscopy. The result is that the crystal structure of the sample irradiated at the dose of 1×10^5 Gy is of an obvious damage while the structure of the unirradiated sample is crystal band. The transformation of the sample which has high crystal degree amorphous one. The melting point and thermal decomposition temperature trend sample's thermal stability drops. The radiation decomposition of the sample is remarkable from crystal state to decline, which indicates that the mainly the rupture of C-C bond, and less is the rupture of C-F bond. The Intensity I₃ of the third lifetime fails with increasing the absorbed dose, which demonstrates the reduction of free volume cave content. Compared with I₃, the rule of τ₃ is reverse.

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