# 摘要

利用直接光聚合(In-situ photopolymerization)的方法在石英晶體微天平(QCM)上製成 PPy 或 $TiO_2$ NPs/PPy 感測薄膜之低濕感測元件。使用場發射掃描式電子顯微鏡系統(FE-SEM)和原子力顯微鏡(AFM)觀察奈米複合材料的表面結構及形態學。研究中主要是利用奈米顆粒 $TiO_2$ 的添加可增加 PPy 在低濕時的感測特性，感度也隨著 $TiO_2$ NPs 添加量的增加呈增加的關係，在濃度 171.12 $ppm_v$ 下 PPy/50 wt.% $TiO_2$ 複合材料薄膜顯現出極好的感濕特性(0.0246 $-\Delta Hz/\Delta ppm_v$)，線性(Rsqr = 0.9576)及在 55.0 $ppm_v$ 濃度下出現很快的反應時間(12 秒)。低濕感測機制主要是藉由複合材料的表面結構及 $TiO_2$ 奈米顆粒之奈米結構形態學兩方面來探討，並且根據吸附動力學理論分析，計算出 PPy 和 PPy/50 wt.% $TiO_2$ 複合材料薄膜的水蒸氣分子結合常數來解釋在低濕感測下 PPy 摻雜 50 wt.% $TiO_2$ 奈米顆粒將隨著添加量的影響使得感度增加，且與水分子有較大的結合常數。

*關鍵字*： 低濕感測器； 光聚作用； 石英晶體微天平；
複合材料； 吡咯/二氧化鈦奈米顆粒；
吸附動力學分析

# Abstract

Novel low humidity sensors were fabricated through in-situ photopolymerization of polypyrrole/$TiO_2$ nanoparticles (PPy/$TiO_2$ NPs) composite thin films on quartz-crystal microbalance (QCM). The characterizations of the thin films were analysed by scanning electron microscopy (SEM) and atomic force microscopy (AFM). The sensitivity increased with increasing the doping amount of $TiO_2$ NPs. The PPy/50 wt.% of $TiO_2$ NPs composite thin films showed excellent sensitivity (0.0246 -$\Delta Hz/\Delta ppm_v$ at 171.12 $ppm_v$), linearity (Rsqr=0.9576) and fast response time (12 s at 55.0 $ppm_v$). The low humidity sensing mechanism was discussed in terms of surface texture and nanostructured morphology of the composite materials. Moreover, based on the adsorption dynamic analysis, the association constant of water vapor molecules with PPy and PPy/50 wt.% of $TiO_2$ NPs composite thin films were estimated to be 81.609 and 227.867 $M^{-1}$, respectively, thus explaining the effect of adding 50 wt.% $TiO_2$ NPs into PPy in the increased sensitivity of low humidity sensing with larger association constant.

*Keywords:* Low humidity sensor; photopolymerization; quartz-crystal microbalance; composite material; polypyrrole/$TiO_2$ nanoparticles; adsorption dynamic analysis.