Piezoelectric properties of hot compression molded PVDF/SiC nanocomposites

Mina Rasoolzadeh, Zahra Sherafat

Department of Materials Science and Engineering, School of Engineering, Shiraz University, Shiraz, Iran

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ABSTRACT

Poly(vinylidene fluoride), PVDF, has been studied extensively because of its outstanding piezoelectric properties. PVDF shows five crystalline polymorphs known as α, β, γ, δ, and ε phases. Among them, the β phase exhibits piezoelectric properties, but the α phase is thermodynamically more stable. The incorporation of additives into PVDF can promote β phase formation. In this study, PVDF-nano SiC composites with different SiC contents were fabricated through hot compression molding and the effects of SiC on the crystal structure, crystallinity and piezoelectric properties of PVDF were studied. The microstructure of the composite samples was investigated by SEM. The prepared samples were perfectly dense with a density more than 97% of the theoretical density. The amount of β phase was determined by FTIR analysis and the crystallinity of the PVDF was deduced from DSC analysis. Finally the piezoelectric properties of the samples were measured by a piezotester. The results showed that by increasing SiC content up to 1 wt%, the amount of β phase, crystallinity and sensitivity of the samples increased and then decreased afterwards.

PVDF

α | β | γ | δ | ε

β PVDF

Flexibility
Biocompatibility
Piezoelectric, Dielectric, Ferroelectric [1- 2]

- **Mechanical stretching**
- **Applying high pressures**
- **The use of polar solvents**
- **Melt injection**
- **The addition of additives**
- **Polarization under high electric field**
- **Use of copolymers**
- **The addition of nanoparticles**
- **Solvent casting**
- **Electrospinning [3]**

OBJECTIVES

In most studies, casting, as an appropriate method for the production of sheets and thick films, have been selected to investigate the effect of SiC on the piezoelectric properties of the PVDF-SiC composites. However, casting is not suitable for producing thick components, and the hot compression molding can be alternatively used for this purpose. In this study, by adding SiC nanoparticles to polyvinylidene fluoride and fabricating the composite using hot compression molding, the effect of SiC on the formation of the β-phase in PVDF and the piezoelectric properties of the composite has been investigated.

MATERIALS & METHODS

PVDF + **SiC**

Hot Compression Molding

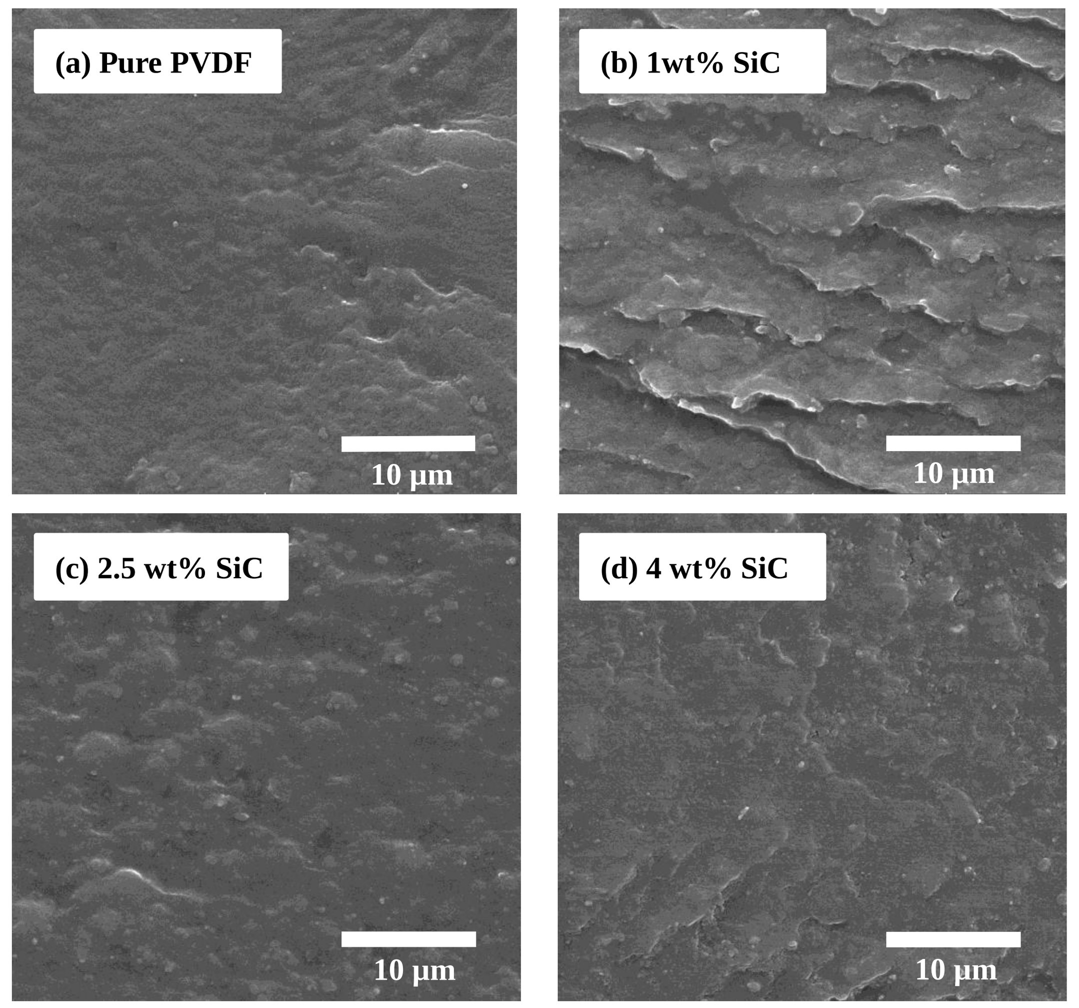
Density | **SEM** | **FTIR** | **DSC** | **Piezoelectric properties**

RESULTS

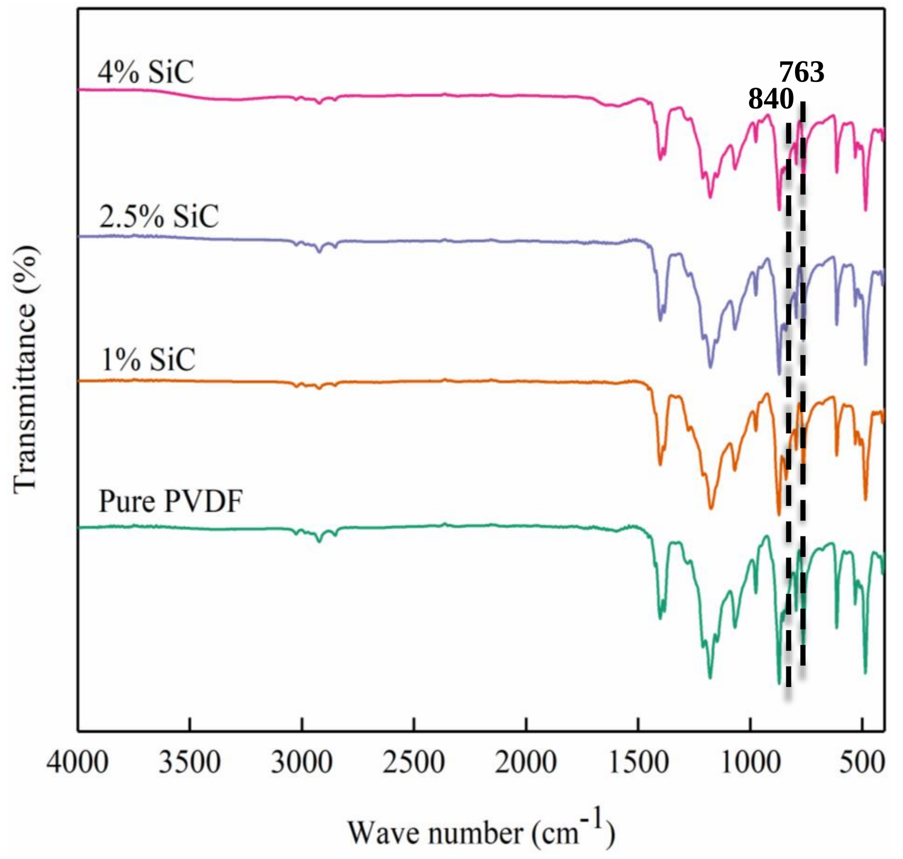
Density of composite samples

Sample	SiC (wt%)	ρ (g/cm³)	ρ_{th} (g/cm³)	ρ/ρ_{th} (%)
1	0	1.732	1.780	97.30
2	1	1.742	1.788	97.42
3	2.5	1.791	1.800	99.49
4	4	1.758	1.812	97

SEM images of the fracture surfaces of composite samples

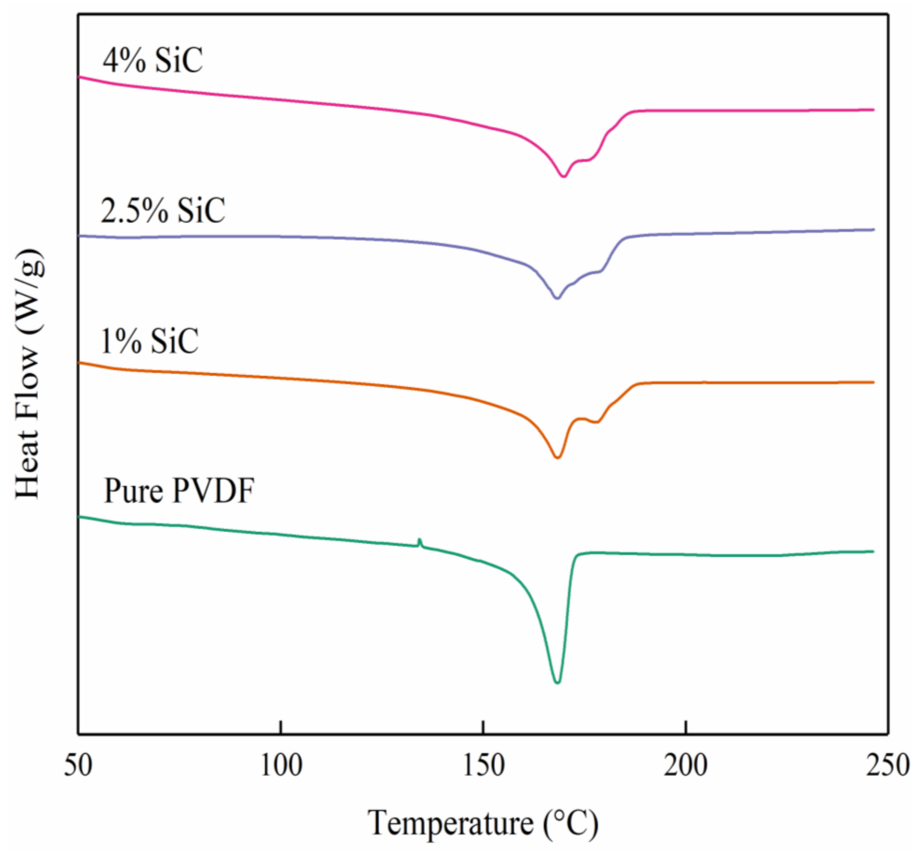


The fraction of the β-phase of the composite samples determined by FTIR analysis



SiC (wt%)	Beta fraction
Pure PVDF	0.33
1% SiC	0.47
2.5% SiC	0.4
4% SiC	0.37

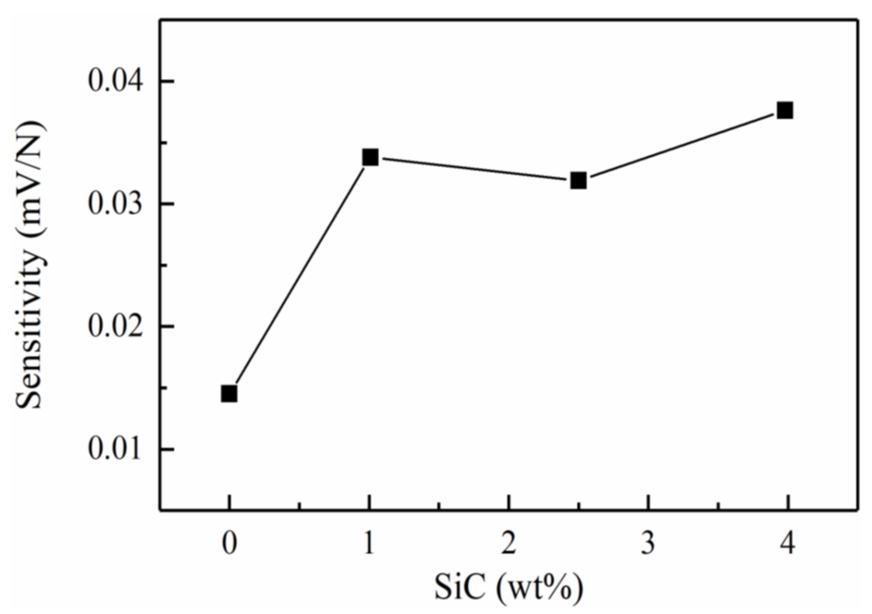
Melting temperature and the degree of crystallinity of the composite samples deduced from DSC analysis



SiC (wt%)	T_m (°C)	ΔX_c (%)
Pure PVDF	168.45	38.56
1% SiC	168.51	41.47
2.5% SiC	168.26	39.86
4% SiC	170.02	37.77

RESULTS

Piezoelectric properties of composite samples



CONCLUSIONS

❶The SEM images and the density of the composite samples fabricated by hot compression molding indicate that this method is appropriate for producing dense and pore-free components.

❷The results show that the addition of SiC up to 1 wt% increases the β-phase. Further increase in the amount of SiC, due to the agglomeration of particles, decreases the amount of the β-phase.

❸The results of the DSC test show that the highest percentage of crystallinity is obtained in the sample containing 1 wt% SiC.

❹ The results of the piezoelectric behavior show that with increasing the amount of SiC up to 1 wt%, the piezoelectric property of the sample enhances while no significant changes were noticed beyond 1 wt% SiC.

REFERENCES

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CONTACT INFORMATION

Corresponding Author:
Dr Zahra Sherafat
Email: zsherafat@shirazu.ac.ir