SUPPORTING INFORMATION

Flexible PVDF-NCMF Nanocomposites: A Synergistic Approach to Enhanced Magneto-Dielectric Properties and Sensing Performance.

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PVDF-NCMF Composites - Williamson Hall Plots & Analyses:

The Williamson-Hall (W-H) methodology considers strain-induced XRD peak broadening. This approach estimates crystal size based on intrinsic strain. Nanocrystallite size and microstrain induce physical line broadening of the X-ray diffraction peak can be expressed as:

$$\beta_{hkl} = \beta_D + \beta_\varepsilon \text{ ---------- (1)}$$

where β_D and β_ε are the size and strain induced broadening in the peaks respectively. β_{hkl} is the Full Width at Half Maximum (FWHM) of the highest peak (in radians) and calculated using the renowned Debye-Scherrer's formula as given below.

$$D = \frac{K\lambda}{\beta_{hkl} COS\theta} \text{ --------------(2)}$$

Here D is the crystallite size, K is the Scherrer constant or shape factor, λ=1.540598 Å is the wavelength of the x-rays and θ is Bragg's angle. β_ε the strain induced broadening of the XRD pattern can be calculated using the below mentioned equation,

$$\beta_\varepsilon = 4\varepsilon \, . \, \tan\theta \text{ ---------------(3)}$$

where ε is the microstrain. Under the assumption that both particle size and strain contribute independently to line broadening and follow a Cauchy like profile, the observed phenomenon of line broadening in different planes can be well described by the sum of equations (2) and (3) as follows.

$$\beta_{hkl} = \frac{K\lambda}{DCOS\theta} + 4_\varepsilon \, . \, tan\theta \text{ ----(4)}$$

After rearranging Eq. 4 can be written as

$$\beta_{hkl} cos\theta = \frac{K\lambda}{D} + \varepsilon . 4sin\theta \text{ ----(5)}$$

The eq. 5 is known as W-H equation under the assumption that uniform strain is exerted along all the axis of the crystal. As eq. 5 is of the form of straight line, by plotting a graph between β_{hkl} cosθ along y-axis and 4sinθ along x-axis of different volume percentage of NCMF, as shown in Figure S1. The microstrain ε can be calculated from the slope of the linear graph and the crystallite size from the intercept. The values are tabulated in Table S1.

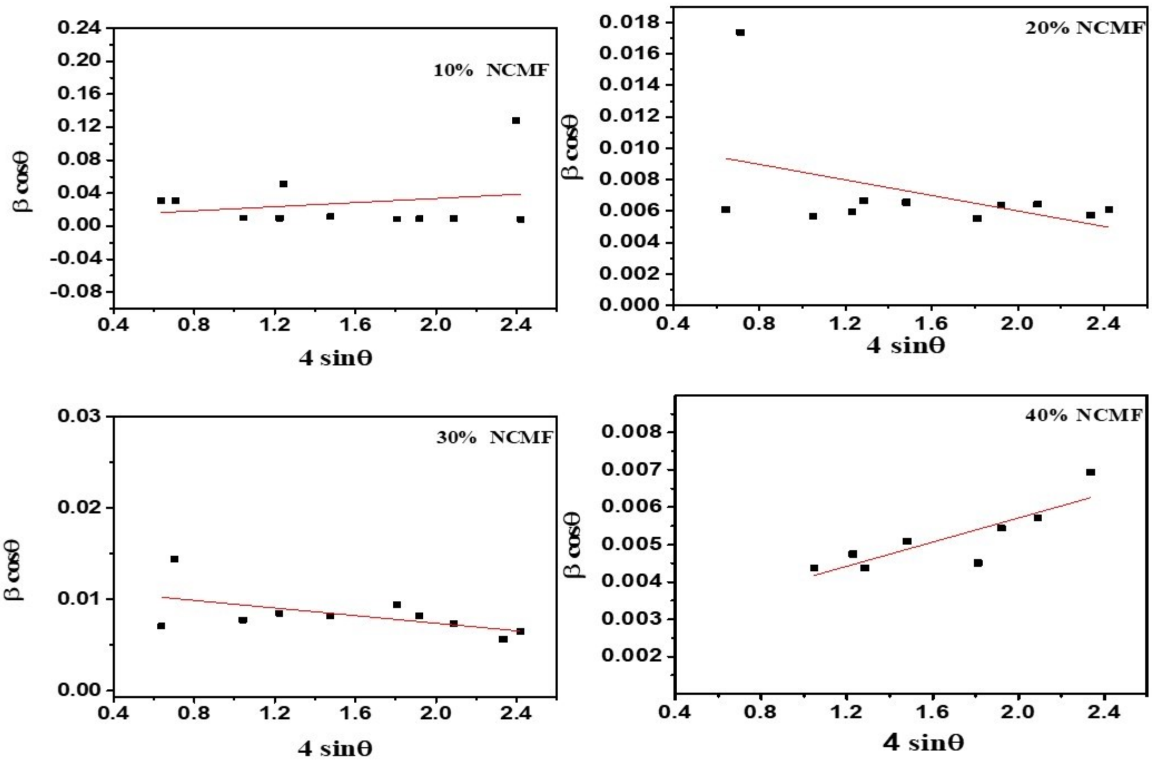

Fig. S1. Williamson-Hall plots of PVDF-NCMF nanocomposites. The data shown are for samples with different volume percentage of NCMF.

Table S1. The strain and average crystallite size of PVDF-NCMF nanocomposites determined from W-H plots.

Volume percentage of NCMF	**Strain**	**Crystallite size (nm)**
10	0.01252	16.83912
20	-0.00247	13.22524
30	-0.00208	12.52737
50	0.000124	30.943675

PVDF-NCMF Composites – Raman Spectroscopic Data & Analyses:

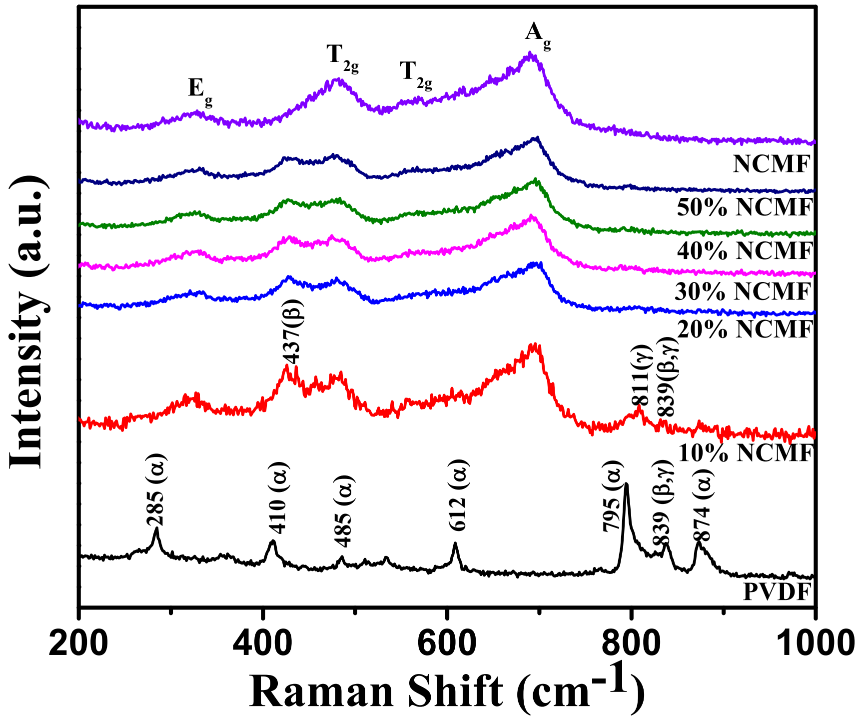

Fig. S2. Raman spectroscopic data of PVDF-NCMF nanocomposites. The data shown are for samples with different volume percentage of NCMF. The peaks identified are as labelled.

Table S2. Raman modes observed and their assignment of PVDF-NCMF nanocomposites.

Compound	Bands (cm^{-1})	Assigned vibration/ Mode	Phase/Polyhedra
PVDF	285	CH_2-Twisting	α-phase
	485	CF_2-Deformation	
	612	CF_2-Wagging	
	410, 795	CH_2-Rocking	
	874	CC- symmetric stretching	
	437	CF_2-Rocking	β-phase
	811	CH_2-Wagging	γ- phase
	839	CH_2-Rocking & CF_2-Stretching	β and γ phase
NCMF	322	E_g	FeO_6 Octahedra
	480	$T_{2g}(2)$	
	571	$T_{2g}(3)$	
	695	A_g	FeO_4 Tetrahedra

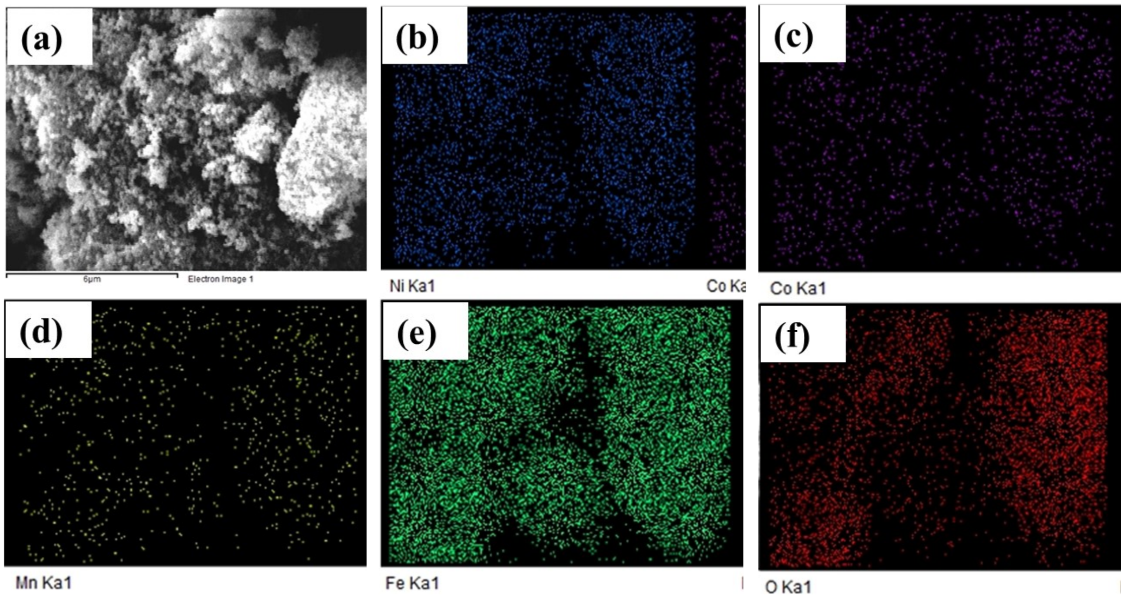

Fig. S3. SEM micrograph of (a) NCMF nano powder, Energy dispersive spectroscopy of NCMF nano powder with elemental maps of (b) Ni Kα1, (c) Co Kα1, (d) Mn Kα1, (e) Fe Kα1and (i) O Kα1.

Table S3. EDS elemental composition of NCMF nano powder

Element	Weight %	Atomic %
Ni Kα1	20.46	10.36
Co Kα1	0.99	0.50
Mn Kα1	1.49	0.81
Fe Kα1	41.40	22.05
O Kα1	35.66	66.28