Impact of electrical conductivity on the electrochemical performances of layered structure lithium trivanadate ($LiV_{3-x}M_xO_8$, M= Zn/Co/Fe/Sn/Ti/Zr/Nb/Mo, x= 0.01-0.1) as a cathode materials for Energy storage

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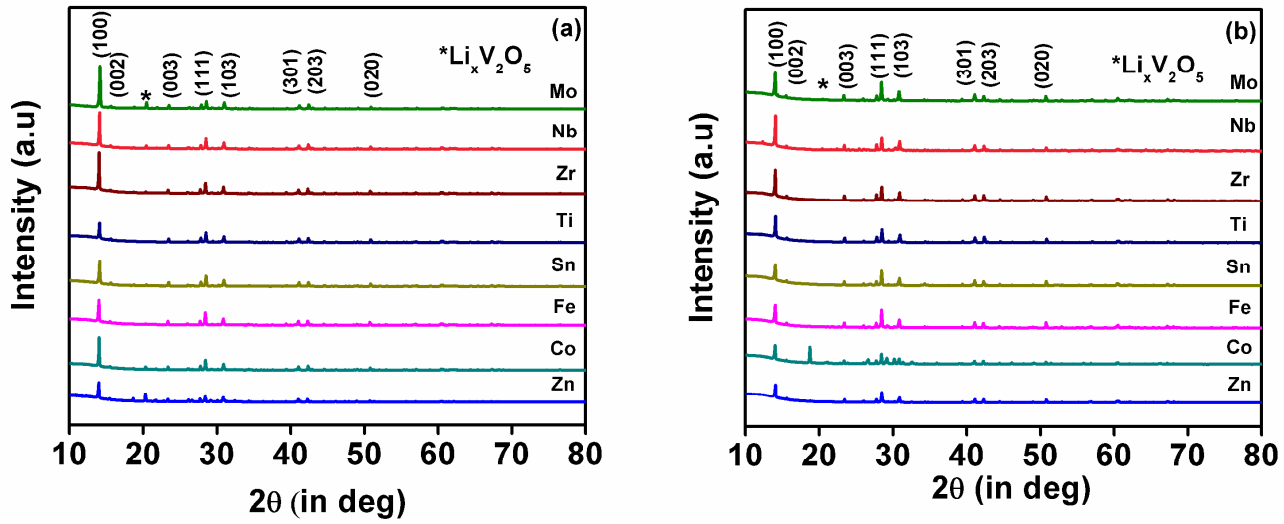

Figure.S1 (a) XRD pattern of $LiV_{2.99}M_{0.01}O_8$ and (b) $LiV_{2.9}M_{0.1}O_8$ (M = Zn/Co/Fe/Sn/Ti/Zr/Nb/Mo) compounds

The XRD patterns of the $LiV_{2.99}M_{0.01}O_8$ and $LiV_{2.9}M_{0.1}O_8$ (M = Zn/Co/Fe/Sn/Ti/Zr/Nb/Mo) compounds are shown in Figure.S1 (a and b), respectively. The XRD patterns of all the compounds correspond to the layered monoclinic crystalline phase with space group *P*21/*m*. The lattice parameters values of all the compounds were found closely matched with JCPDS Card No: 72-1193.

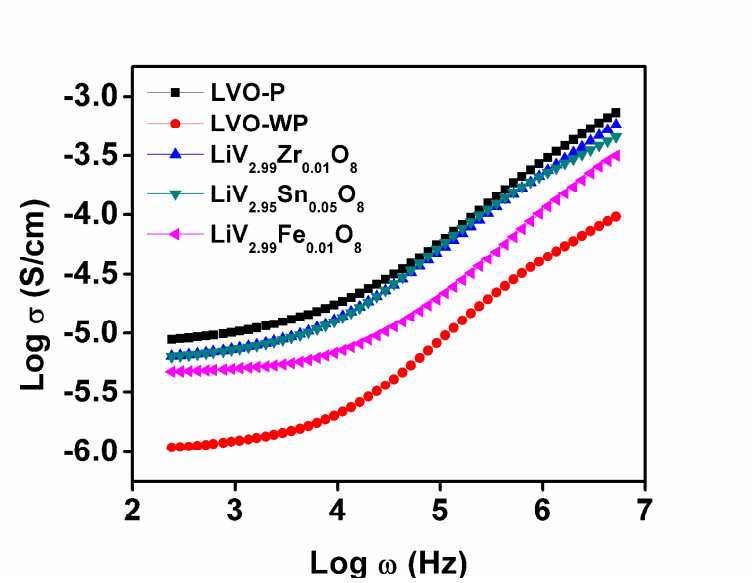

Figure.S2 Conductivity spectra of LVO-P, LVO-WP, $LiV_{2.99}Zr_{0.01}O_8$, $LiV_{2.95}Sn_{0.05}O_8$ and $LiV_{2.99}Fe_{0.01}O_8$ compounds

Figure.S2 represents frequency dependent conductivity spectra of the Pristine LVO and selected compounds, taken at room temperature (303 K) for the frequency range 42 Hz to 1 MHz. Within the measured frequency range, the observed conductivity spectra have two distinct regions. The frequency independent plateau region represents the dc conductivity (σ_{dc}) of the sample and the σ_{dc} values extrapolated from the plateau region are given in Table.2. The higher frequency (>10 KHz) dispersion region was attributed to the bulk relaxation phenomena.

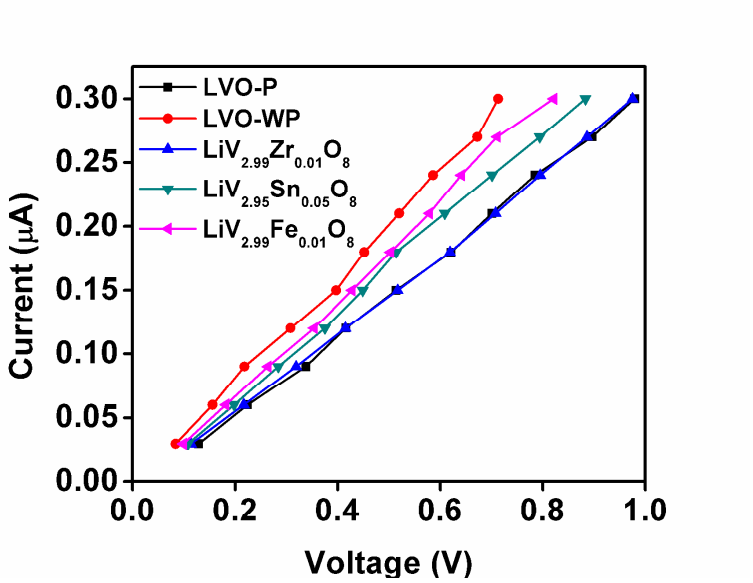

Figure.S3 V/I spectra of LVO-P, LVO-WP, $LiV_{2.99}Zr_{0.01}O_8$, $LiV_{2.95}Sn_{0.05}O_8$ and $LiV_{2.99}Fe_{0.01}O_8$ compounds

The voltage vs. current (*V/I*) plot for the selected compounds taken at room temperature, using 4-probe *DC* measurement is shown in Figure S3. The current (*I*) and voltage (*V*) taken from the 4-probe *DC* measurements were used to calculate the conductivity by the expression,

$$\sigma_{dc} = \left(\frac{I}{V}\right)\left(\frac{l}{A}\right)$$

Where "l" and "*A*" are the distance between the probes and the area of the sample, respectively. The electrical conductivity values were calculated and given in Table 2. The values closely matched to the data in conductivity spectra and followed the same trend, validating the electrical measurements.

Compound	*Interlayer distance (d_{100})* (nm)		
	0.01 M	0.05 M	0.1 M
LVO-P	**0.6352**		
Zn	0.6374	0.6324	0.6338
Co	0.6356	0.6324	0.5950
Fe	**0.6370**	0.6334	0.6338
Sn	0.6324	**0.6366**	0.6338
Ti	0.6328	0.6328	0.6328
Zr	**0.6360**	0.6356	0.6342
Nb	0.6324	0.6334	0.6338
Mo	0.6298	0.6338	0.6338

Table S1. Comparison of interlayer distance

Interlayer distance of the (100) plane for all the compounds is shown in Table S1. On comparison with LVO-P, the shift in peak corresponding to the (100) plane either towards the higher or lower 2θ angle, was confirmed for all the doped compounds. Shifting of the peak corresponding to the (100) plane towards lower 2θ angle indicates the increase in interlayer distance d_{100} and vice versa.