Section S1: Estimation of oxidation state of ions in unknown compounds.

In most of the cases, half of step height is used for estimation of oxidation state[1,2]. Here, example of oxidation state estimation of Mn ions in Ru doped MnO_2 from XANES spectra is given (Fig. S1a). The main edge energy is estimated from the 0.5 of normalize absorbance (Fig. S1a: inset). Fig. S2b shows the main edge energy of standard materials and these materials. Standard materials exhibit a linear relation among the edge energy and their oxidation state. From the main edge energy of *β*-(Mn,Ru)O_2 the oxidation state is estimated and shown in Fig. S2b inset.

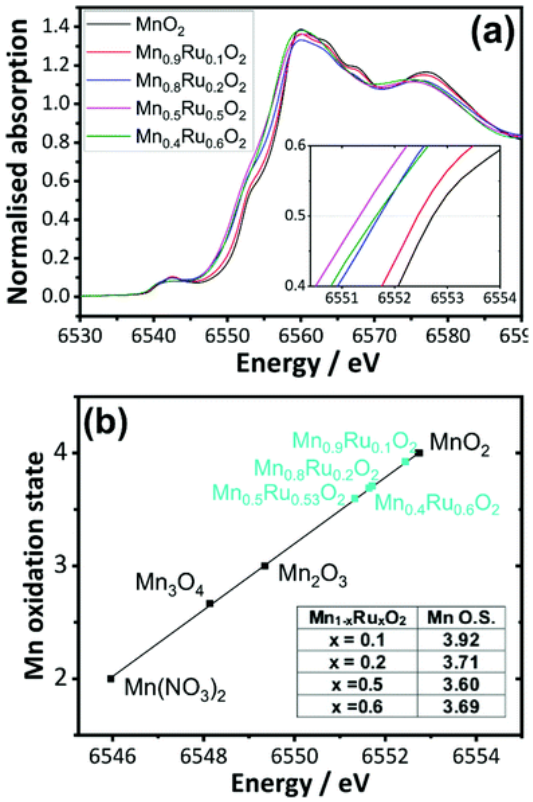

Fig. S1: (a) Mn K-edge XANES spectra of *β*-(Mn,Ru)O_2 materials, with the inset showing the region used to determine edge position, and (b) determination of Mn oxidation state with reference to model compounds in which the line is fitted by linear regression to the edge positions of the model compounds.

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2. **Lucy K. McLeod, Geoffrey H. Spikes, Reza J. Kashtiban, Marc Walker, Alan V. Chadwick,d Jonathan D. B. Sharman and Richard I. Walton, Structures of mixed manganese ruthenium oxides ($Mn_{1-x}Ru_x$)O_2 crystallized under acidic hydrothermal conditions, Dalton Trans., 2020,49, 2661-2670**