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Superconductivity in Organic-Ion Intercalated MoS_2

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MoS_2 exhibits degenerate semiconductor behavior characterized by exotic phenomena such as charge density waves (CDWs) or superconductivity when doped within a specific range of charge carrier concentrations.[1] Achieving this carrier doping level typically involves ionic-liquid gating or alkali-ion intercalation.[2,3] However, the potential of organic intercalation of transition metal dichalcogenide to reach similar milestones remains largely unexplored. Organic chemistry offers an extensive range of intercalating compounds, potentially capable of inducing novel, exotic electronic behaviors that would otherwise be unachievable with inorganic intercalates. Here, we present the first observation of superconductivity and a CDW state emerging in MoS_2 intercalated using Cetyltrimethylammonium Bromide (CTABr) and tetraethylammonium Bromide (TEABr). We demonstrate that these correlated electronic phases depend significantly on the intercalated cation. A fully developed zero-resistance state is only observed in bulk crystals, but not in thin flakes of TEA-intercalated MoS_2. We attribute this effect to the presence of 3D superconductive paths, which are severed upon mechanical exfoliation of the crystals. Our results establish organic-ion intercalated MoS_2 as a platform to study the emergence and modulation of correlated electronic phases.[4]

References

[1] J. T. Ye, Y. J. Zhang, R. Akashi, M. S. Bahramy, R. Arita, Y. Iwasa, Science, 338, (2012), 1193
[2] R. B. Somoano, V. Hadek, A. Rembaum, S. Samson, J. A. Woollam, J. Chem. Phys. 62, (1975), 1068
[3] D. Costanzo, S. Jo, H. Berger, A. F. Morpurgo, Nat. Nanotechnol. 11, (2016), 339
[4] J. M. Pereira, D. Tezze, I. Niehues, Y. Asensio, H. Yang, L. Mester, S. Chen, F. Casanova, A. M. Bittner, M. Ormaza, F. Schiller, B. Martín-García, R. Hillenbrand, L. E. Hueso, M. Gobbi, Adv. Funct. Mater. 2208761 (2022)

Figures

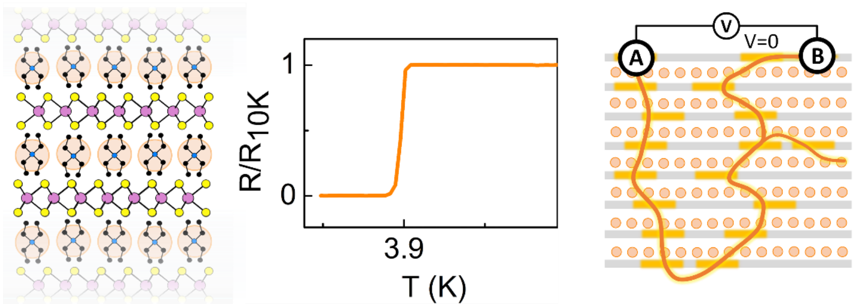

Figure 1: The intercalation of TEA^+ cations in MoS_2 leads to the emergence of superconductivity in bulk MoS_2 due to the formation of percolating path resulting from the alignment of nanoscale-sized highly doped regions located in contiguous layers.