Conclusion

We have shown in this review the synthesis, structure and magnetic properties of Mn₄₅ clusters that have been developed up till now. This review has proven an invaluable source of collective data on this fascinating and interesting phenomenon. Various methods are now available for the preparation and the controlled modification of Mn₄₅ molecules. These methods provide an array of various SMMs for all types of studies. Except Mn₄₅ family, no other SMM type has such a large degree of controlled modification been accomplished.

The use of Mn₄₅ has been illustrated to bind them because of its controlled modification in a number of ways. There are many interesting studies of the Mn₄₅ family in the physics and related literature. Nevertheless, there are probably more Mn₄₅ papers in the physics than the chemistry literatures, owing to the many studies of what are nanoscale magnetic particles that have become possible from the availability of crystalline, monodispersive, often identically-oriented assemblies of SMMs.

Single molecular magnets have opened possibility for the study of physical phenomena at the edge between the microscopic quantum world and the macroscopic classical regime. Experimentally, SMMs provide a signature of quantum mechanical behavior which is derived from a combination of large spin (S) and easy axis anisotropy. SMMs also have the application feature such as in quantum computation. The effort has been in developing the SMMs with higher blocking temperature for the practical use in the upcoming generation quantum computer and magnetic data storage. Various experimental techniques have been successfully used for the study of these systems; yet, there is still requirement of neat theory to describe them.
Conclusion

We have shown in this review the synthesis, structure and magnetic properties of Manganese clusters that have been developed up till now. This review has proven an invaluable source of collective data on this fascinating and interesting phenomenon. SMMs are interesting materials retaining all the advantages of molecular chemistry. Various methods are now available for the preparation and the controlled modification of \( \text{Mn}_{12} \) molecules. These methods provide an array of various SMMs for all type of studies. Except \( \text{Mn}_{12} \) family, for no other SMM type has such a large degree of controlled modification been accomplished.

The use of \( \text{Mn}_{12} \) complexes in more intricate experiments, such as attempts to bind them to surfaces or between nano-electrodes, has become possible because of its controlled modification in a number of ways. There are many interesting studies of the \( \text{Mn}_{12} \) family in the physics and related literature. Nevertheless, there are probably more \( \text{Mn}_{12} \) papers in the physics than the chemistry literature, owing to the many studies of what are nanoscale magnetic particles that have become possible from the availability of crystalline, monodisperse, often identically-oriented assemblies of SMMs.

Single molecular magnets have opened possibility for the study of physical phenomena at the edge between the microscopic quantum world and the macroscopic classical regime. Experimentally, SMMs provide a signature of quantum mechanical behavior which is derived from a combination of large spin (S) and easy axis magneto-anisotropy. SMMs also have the application feature such as in quantum computation. The effort has been in developing the SMMs with higher blocking temperature for the practicable use in the upcoming generation quantum computers and magnetic data storage. Various experimental techniques have been successfully used for the study of these systems; yet, there is still requirement of neat theory to describe them.
We conclude by pointing out that the Mn$_{12}$ compounds are SMMs at the very low temperatures (liquid He and below). This means that these molecules themselves are unlikely to ever find serious technological application. However, that does not reduce their importance. The field of superconductivity began with the discovery in 1911 of this new phenomenon in elemental mercury, and although the latter was never employed as a superconductor in a commercial device, that does not diminish the importance of mercury to that field; after all, it was the trial product of a whole new field of materials which provided the first example for serious study.

The Mn$_{12}$ clusters hold a similar position within the new field that has come to be known as single-molecule magnetism. However, there is a very big difference between superconductivity and single-molecule magnetism: there are no room temperature superconductors, which is driving the search for higher and higher $T_C$ materials, but there are already many truly excellent room temperature magnets, some of which have been known for over two thousand years, and which are in ever-present use in all areas of our modern world.

Whatsoever the future may hold for SMMs, it is unlikely that at room temperature, SMM will do any job for mass use in room temperature applications. Instead, their future is certainly in low-temperature and highly specialized ones that make use of their molecular advantages of size, crystallinity, and well-defined quantum properties, and for which the expense of working at low-temperature is insignificant compared to the benefits of the application.