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Theranostic Viral Nanoparticles for Autoimmune Diseases

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Abstract

Viral Nanoparticles (VNPs) as theranostic tools are a rapidly growing aspect of these particular types of nanoparticles. Among their multiple possible applications, their contribution in the field of autoimmune diseases has recently emerged, since they can increase the sensitivity of detection of autoantibody levels significantly allowing early diagnosis, prognosis and, consequently, the development of specific therapies. Based on the promising results obtained using nanoparticles derived from Turnip Mosaic Virus (TuMV) in an animal model of Inflammatory Bowel Disease (IBD), this mini review discusses the possibilities of development of this VNP as a power tool for diagnosis in immune-mediated diseases.

Keywords: Viral nanoparticles (VNPs) • Theranostic • Autoimmunity • Autoantibody

Introduction

Theranostic VNPs (Viral Nano Particles)

An important goal of current biomedical research is to develop good theranostic tools, amenable not only for good diagnostic practices but also for providing assistance to directed therapies. Nano biotechnology has supported many of these developments over recent years, ranging from nano devices or nano materials to individual nanoparticles of a great biotechnological interest [1-6]. Within the large collection of available nanoparticles, viral nanoparticles (VNPs) offer some specific characteristics turning them as an attractive tool for biomedical-related areas, including immunology. VNPs derive from the naturally occurring nanoparticles called virions, the encapsidated form of viruses [7-10]. Thus, VNPs offer a biocompatible and biodegradable nanoparticle option since they are mostly made of proteins [11]. In addition, a large diversity of virions usable as nanoparticles exists, all the way from small icosahedral ones with diameters of few nanometers to elongated flexuous particles which can be almost one-micron long. In any case, the viral capsid can be seen as a derivatizable scaffold, a multiway process including the genetic fusion of peptides or proteins [12-17], the chemical conjugation [18-20] or the encapsidation [21] of different kinds of molecules and amino acid residues.Combinations of derivatizing strategies are also possible, giving rise to multifunctionalization [20].

Biosafety is a central issue in biomedical-related biotechnologies. This also applies to VNPs, so their selection and design must take this into account. VNPs derived from plant viruses appear as an attractive alternative source since they are not pathogens of humans or higher animals [22-25]. In addition to this, the possibility of generating non-infectious Virus-Like Particles (VLPs), and a relatively easy and inexpensive scale-up, make of plant VNPs a good platform for theranostic developments [9,26-29]. Good examples of plant-derived VNPs are those developed from Turnip mosaic virus (TuMV), a flexuous elongated potyvirus. This virus has given rise to several VNPs, both derived from virions and from VLPs, which have shown to form a multi-functionalizable platform with different biomedical applications [15-17,20,30]. One of these implies their use for antibody sensing through the multimeric presentation of antigens on the particle external surface; such that a single particle can display up to approximately 2000 antigen copies [15-17]. This system allows to increase the sensitivity significantly with respect to conventional assays for autoantibody detection such as Enzyme-Linked ImmunoSorbent Assay (ELISA) and Immunofluorescence Assay (IFA), and it can be applied as a diagnostic tool in those pathologies associated to alterations in antibody levels.

The Relevance of Antibody and Autoantibody Sensing

Antibody sensing by highly sensitive tools allow an early prognosis, diagnosis and specific therapeutic approaches as well as the association of antibody levels and the pathological stage in different types of pathologies. VNPs as theranostic tool can be applicable to diseases that course with alterations in the antibody levels such as inflammatory and infectious diseases and cancer. This would be especially useful in pathologies in which change in antibody levels are subtle as occurs in autoimmune diseases [31-35] that course with an immune response directed towards self-molecules, the autoantigens, producing antibodies against them, the so-called autoantibodies.

It is known that many autoimmune diseases are caused by loss of immunologic self tolerance that generates chronic inflammation [33]. A precise and sensitive detection of autoantibodies in autoimmune diseases would help significantly in the understanding of the underlying mechanisms

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