ARTICLE IN PRESS

CIS-01855; No of Pages 20

Advances in Colloid and Interface Science xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Advances in Colloid and Interface Science

journal homepage: www.elsevier.com/locate/cis

Historical perspective

Recent developments in dopamine-based materials for cancer diagnosis and therapy

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ARTICLE INFO

Available online xxxx

Keywords:
Polydopamine
Nanomaterials
Biosensing
Bioimaging
Cancer therapy

ABSTRACT

Dopamine-based materials are emerging as novel biomaterials and have attracted considerable interests in the fields of biosensing, bioimaging and cancer therapy due to their unique physicochemical properties, such as versatile adhesion property, high chemical reactivity, excellent biocompatibility and biodegradability, strong photothermal conversion capacity, etc. In this review, we present an overview of recent research progress on dopamine-based materials for diagnosis and therapy of cancer. The review starts with a summary of the physicochemical properties of dopamine-based materials in general. Then detailed description is followed on their applications in the fields of diagnosis and treatment of cancers. The review concludes with an outline of some remaining challenges for dopamine-based materials to be used for clinical applications.

Contents

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https://doi.org/10.1016/j.cis.2018.01.001
0001-8686/

Please cite this article as: Li H, et al, Recent developments in dopamine-based materials for cancer diagnosis and therapy, Adv Colloid Interface Sci (2018), https://doi.org/10.1016/j.cis.2018.01.001

1. Introduction

Dopamine is a catecholamine that acts as an important neurotransmitter in the nervous system [1]. It plays a critical role in controlling reward and pleasure centers in the brain [2]. Dopamine-based drugs are widely used to treat Parkinson's disease, schizophrenia and addiction. The discovery that L-DOPA, a precursor of dopamine, had an effect on Parkinson's disease was awarded the Nobel Prize in Physiology or Medicine in 2000 [3]. Besides, dopamine has been demonstrated to control the growth and metastasis of several types of malignant tumors, including gastric cancer [4], liver cancer [5] and breast cancer [6, 7]. The antitumor activity of dopamine is mainly achieved through its specific receptors, especially D2R. In gastric cancer, D2R is responsible for inhibition of insulin-like growth factor-I (IGF-I)-induced cancer cell proliferation [8] and for suppression of cancer cell invasion and migration via the EGFR/AKT/MMP-13 pathway [4]. Moreover, D2R has been reported to inhibit angiogenesis through the VEGF receptor 2 [9, 10].

In the past few years, dopamine has attracted considerable interests as a building block for polydopamine (PDA), which has found use as a universal coating material. Inspired by the strong adhesion property of mussel adhesive proteins, Messersmith and co-workers in 2007 reported a robust eumelanin-like coating material prepared by oxidative self-polymerization of dopamine in an alkaline aqueous medium (Fig. 1) [11]. The primary advantage of PDA is that it can attach to almost all material surfaces, including metals, oxides, ceramics, polymers and even Teflon [12]. Another valuable feature of PDA is the high chemical reactivity, including crosslinking with thiol- and amino-terminated molecules via Michael addition or Schiff base reactions and chelating with a variety of metal ions. PDA also has some other interesting properties, such as biocompatibility, reducibility, fluorescence quenching ability and photothermal conversion capability. As a result, dopamine has aroused great interests for preparation and modification of materials in the fields of energy, sensing and water treatment, especially in biomedicine. In this review, we highlight recent advances of dopamine-based

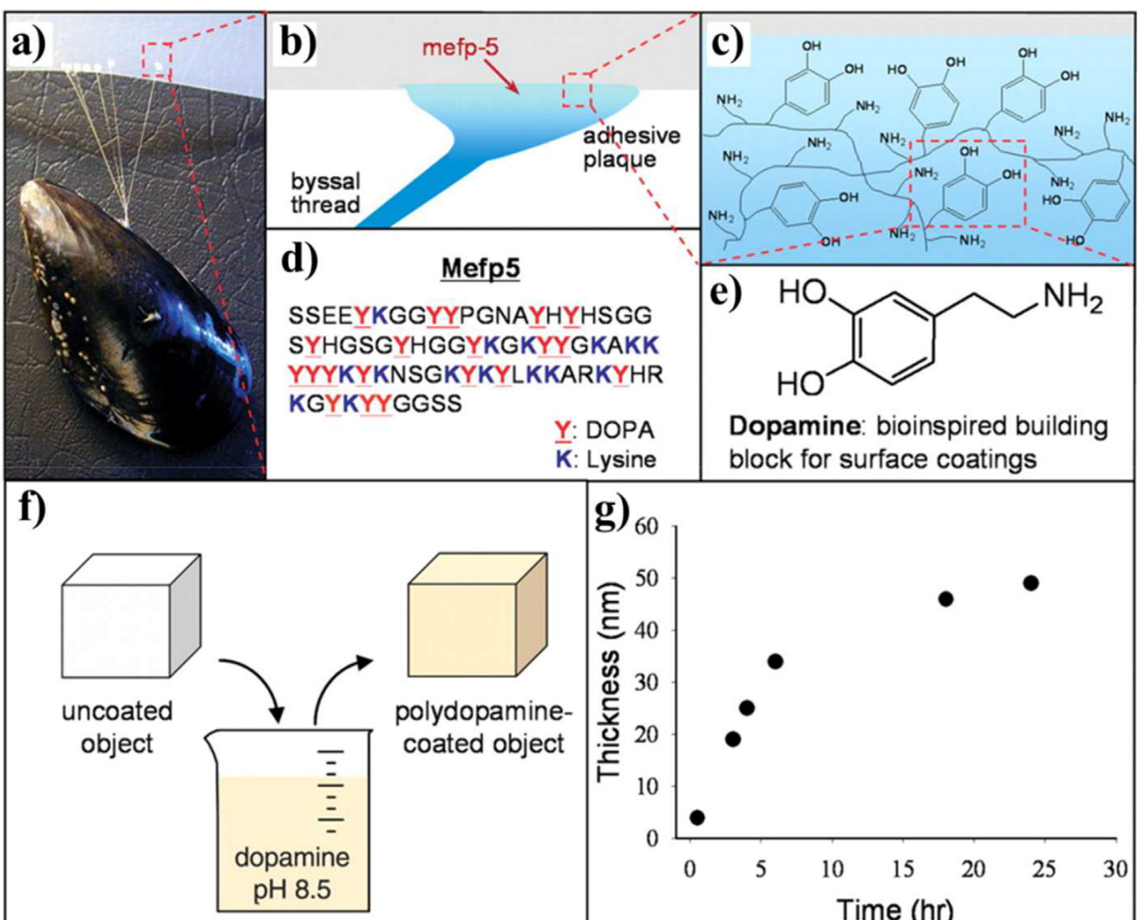

Fig. 1. (a–d) Photograph of a mussel and schematic illustration of the molecular structure of Mefp-5. (f) Schematic illustration of thin film deposition of PDA. (g) Thickness evolution of PDA films on Si. Reprinted with permission from [11] copyright (2007) American Association for the Advancement of Science.

Please cite this article as: Li H, et al, Recent developments in dopamine-based materials for cancer diagnosis and therapy, Adv Colloid Interface Sci (2018), https://doi.org/10.1016/j.cis.2018.01.001