1. As one of the most hazardous heavy metal contaminant, lead ion can cause serious impact on human health and environment. Exposure to lead ion mainly through contaminated water in the environment, leaded gasoline, coal combustion, ceramic production and so on. It can accumulate in the body through skin absorption, digestive tract or food chain, leading to nerve disorder, memory decay, or anemia even at very low level exposure, particularly in children. The World Health Organization (WHO) and the Environmental Protection Agency (EPA) regulate that the maximum acceptable concentration of lead ion in drinking water are respectively 10 and 50 μg/L. Thus, the construction of simple, sensitive and rapid methods for the detection lead ion is of great value. There are many methods to analyze lead ion, such as high performance liquid chromatography (HPLC), atomic absorption spectrometry (AAS), atomic fluorescent spectrometry (AFS) and inductively coupled plasma mass spectrometry (ICP-MS) have been reported for detection of lead ion. Although these conventional analytical methods are highly sensitive and accurate, they are labor-intensive, time-consuming, expensive equipment, which restrict their wide applications. Conversely, electrochemical sensor has been widely utilized in detection of lead ion owing to simple instrument, high selectivity, fast detection and low cost.

2. Aptamer, an artificial synthetic single-stranded DNA or RNA oligonucleotides, are selected in vitro through a SELEX (systematic evolution of ligands by exponential enrichment). Due to binding stability to targets, it has been employed in biosensors to analyze small molecules, heavy metal, proteins or cells. The method of aptamer coupling with electrochemical sensors to detect lead ions has attracted the attention of many researchers. There are different specific aptamers can be used in lead ion aptasensor design. Because all of lead ion aptamer contain lots of guanines, they can product stable G-quadruplexin structure when the presence of lead ion. Based on this unique property, many electrochemical sensors were fabricated for ultrasensitive detection of lead ion.

3. Recently, catalytic hairpin assembly (CHA) as an enzyme-free signal and isothermal nucleic acid amplification strategy have been broadly applied to detection of RNA or DNA in electrochemical sensing platforms, but it has been rarely seen in the detection of heavy metal. CHA is programmed with DNA self-assembly and disassembly reactions, the two hairpin structures can stably coexist without initiator presence. When a single strand DNA as initiator is added, the hairpin structure H1 is opened by base pairing with DNA. Then, due to the hairpin structure H2 has more complementary sequence with opened H1 compared to DNA, H1-H2 complexes are formed and the DNA is displaced participating in another assembly reaction. CHA not only overcomes the disadvantage of enzymatic amplification, but exhibits the high sensitivity, simplifies the reaction conditions and reduces the experimental costs.

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4. In this work, a novel electrochemical sensor based on catalytic hairpin assembly (CHA) has been developed to detect lead ion. We select T30695 aptamer as lead ion specific aptamer. As shown in Scheme 1, the signal amplification strategy was conducted as follows: firstly, in the presence of lead ion, lead ion aptamer was transformed stable G-quadruplex structure with lead ion, leading to the release of cDNA. Then, the released cDNA opened and hybridized with thiol-modified hairpin probes (HP1) that were immobilized on the Au electrode. After another hairpin probes (bio-HP2) was added electrode, cDNA liberated from HP1 for the next cycle process and HP1/bio-HP2 duplex stucture are formed. When the cyclic process completed, there are a large number of capture probe ( HP1/bio-HP2 ) left on the electrode. Finally, amounts of PtNPs@CS-SA by the specific recognition between HP2 modified biotin and streptavidin (SA) were immobilized on the electrode. Thus, a significantly amplified currene is obtained.



作为重金属的污染物之一，铅离子会对环境和人体造成危害。铅离子主要通过煤燃烧、尾气排放、陶瓷制造暴露到环境中去。它可以通过皮肤吸收、消化道或食物链在人体内蓄积，即使在很低的暴露水平下也会导致神经障碍、记忆衰退或者贫血。因此，急需一种快速且灵敏的检测方法对铅离子进行分析。目前已经有许多方法用于检测铅离子，例如高效液相色谱法、AAS、等已经被报道用于检测铅离子。虽然这些传统的分析方法灵敏度高且能达到检测铅离子的目的，但是它们费人工、费时和设备昂贵，且不能进行现场检测。相反，电化学传感器由于灵敏，，设备简单、易于现场检测而被广泛应用于铅离子检测中。

纳米材料的应用（多孔碳、铂）文献调研

纳米材料由于其比表面积大、催化性，，等已经被广泛应用于电化学传感器中。

由于多孔碳具有，，，

Pt 纳米材料可催化性等其他优点(先不写，材料没确定)

铅离子作为最危险的重金属污染物之一，对人体健康和环境有很大的影响。铅离子的暴露主要是通过环境中的污染水，含铅汽油，燃煤，陶瓷制造等。它可以通过皮肤吸收，消化道或食物链积聚在体内，导致神经紊乱，记忆衰退或贫血，即使在非常低的水平暴露，特别是在儿童。世界卫生组织（WHO）和环境保护局（EPA）规定，铅离子的最大可接受浓度分别为10和50μg/ L.因此，用于检测铅离子的简单，灵敏和快速方法具有重要价值。有许多分析铅离子的方法，如高效液相色谱法（HPLC），原子吸收光谱法（AAS），原子荧光光谱法（AFS）和电感耦合等离子体质谱法（ICP-MS）已被报道用于铅的检测离子。虽然这些传统的分析方法是高度敏感的并且可以达到检测铅离子的目的，但是它们是劳动密集的，耗时的，设备费用，这限制了它们的广泛应用。相反，由于设备简单，检测速度快，成本低，电化学传感器已广泛应用于铅离子检测。

适体，人工合成的单链DNA或RNA寡核苷酸，通过SELEX体外选择（通过指数富集系统进化配体）。 由于其对靶标的结合稳定性，它已被用于生物传感器中以分析小分子，蛋白质或细胞。 将适体与电化学传感器结合以检测铅离子的方法引起了许多研究者的关注。有不同的适体可用于铅离子适体传感器设计。 因为所有的铅离子适体都含有许多鸟嘌呤，它们可以在铅离子存在下产生最稳定的G-四联体结构。

最近，催化发夹组装（CHA）作为一种无酶信号和等温核酸扩增策略已被广泛应用于电化学传感平台中RNA或DNA的检测，但它在重金属中很少见。 CHA用DNA自组装和拆卸反应编程，两个发夹结构可以稳定共存而不需要引发剂存在。 当加入单链DNA作为引发剂时，通过与DNA碱基配对打开发夹结构H1。 然后，由于发夹结构H2与DNA相比具有与暴露的H1更多的互补序列，形成H1-H2复合物并且DNA被置换参与另一个组装反应。 CHA不仅克服了酶促扩增的缺点，而且具有高灵敏度，简化了反应条件，降低了实验成本。

在这项工作中，已经开发出一种基于催化发夹组件的新型电化学传感器来检测铅离子。 如方案1所示，信号放大如下进行：首先，在铅离子存在下，铅离子适体与铅离子形成G-四链体结构，导致cDNA的释放。 其次，释放的cDNA打开并与固定在Au电极上的发夹探针（HP1）杂交。 在另一个发夹探针（HP2）加入电极后，从HP1释放cDNA用于下一个循环，并形成HP1-HP2复合物。当循环过程完成时，电极上存在大量HP1-HP2双链结构。