第十四届李曼中国养猪大会

口蹄疫病毒样颗粒组装机 制及免疫特性的研究
Research on the assembly mechanism and immune characteristics of foot-and-mouth disease virus-like particles

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- 时　　间：2025年10月

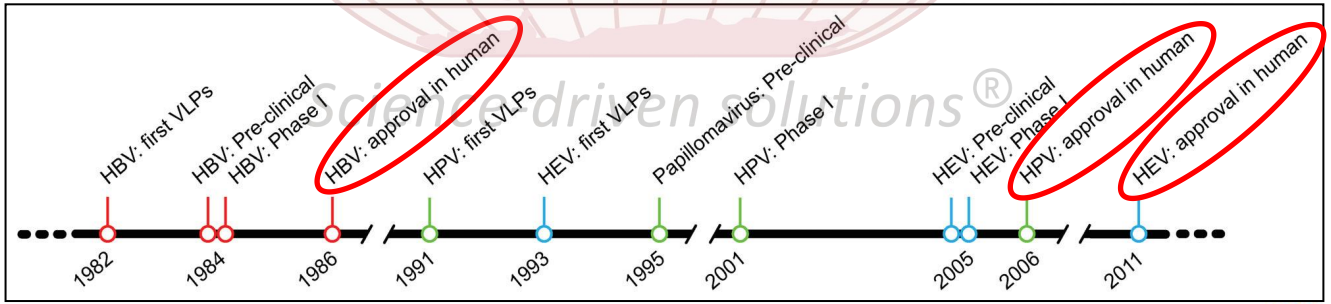
目·录

PART 1

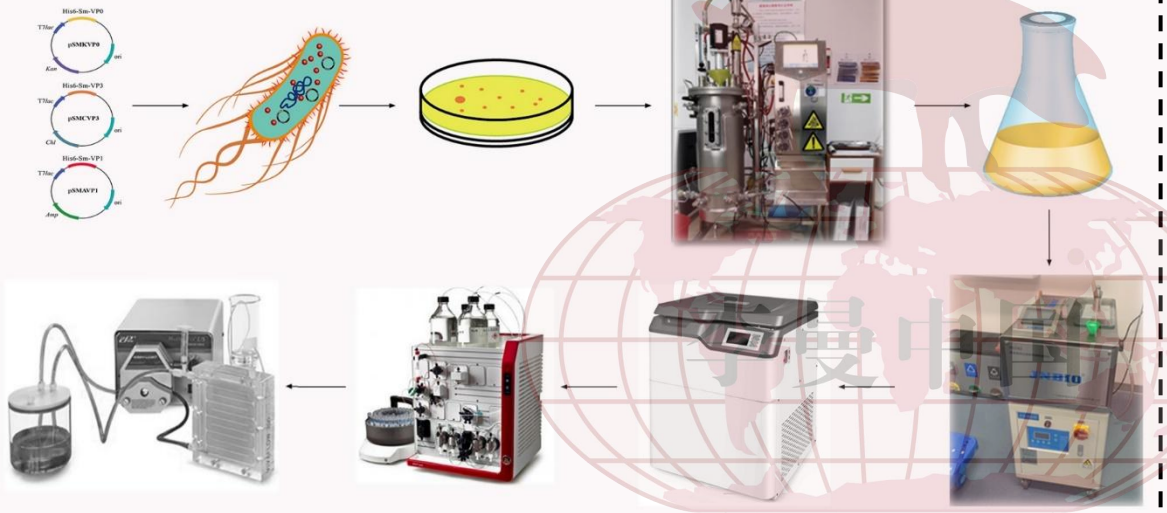
研究背景
Research Background

病毒样颗粒（VLPs）

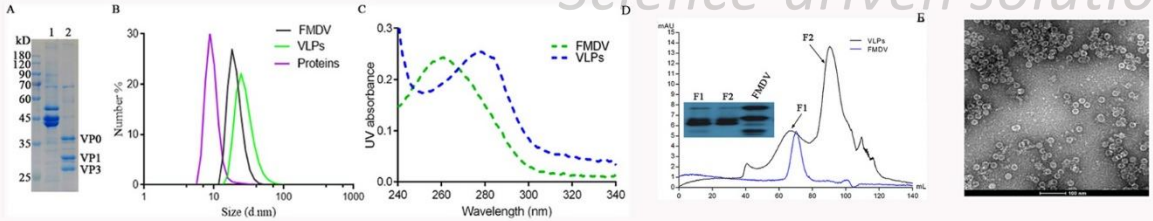
病毒样颗粒（Virus-like particles, VLPs）是一种由病毒结构蛋白组成但不含病毒核酸、不能自主复制的颗粒。Virus-like particles (VLPs) are particles composed of viral structural proteins but without viral nucleic acids and unable to replicate autonomously.



A 口蹄疫病毒样颗粒制备、纯化工艺示意图



B 口蹄疫病毒样颗粒表征



技术优势
Technical advantage

- 无需高致病性生产资质
- No need for high pathogenicity production qualification
- P1-2A聚合体原核表达困难，表达量低，且P1蛋白后期加工存在技术瓶颈
- Prokaryotic expression of P1-2A polymer is difficult, with low expression levels, and there are technical bottlenecks in the later processing of P1 protein
- 单个VP1蛋白体外以包涵体形式表达
- Expression of single VP1 protein in vitro in the form of inclusion bodies

"口蹄疫病毒样颗粒疫苗：领先一代的防控利器"

"Foot-and-mouth disease virus-like particle vaccine: a leading generation of prevention and control tool"

口蹄疫病毒样颗粒疫苗是世界上首个由三个结构蛋白在无细胞体系内自组装成的病毒样颗粒疫苗，获得2项一类新兽药证书。

The foot-and-mouth disease virus-like particle vaccine is the world's first virus-like particle vaccine self-assembled from three structural proteins in a cell-free system, and has obtained two Class I new veterinary drug certificates.

中华人民共和国

新兽药注册证书

证号：（2021）新兽药证字 58 号

新兽药名称：猪口蹄疫O型病毒样颗粒疫苗

注册分类：一类

研制单位：中国农业科学院兰州兽医研究所、华宇生物科技（腾冲）有限公司、中农威特生物科技股份有限公司、天津威特生物医药有限责任公司、华派生物工程集团有限公司

根据《兽药管理条例》，该兽药符合规定，准予注册，特发此证。

发证日期：二〇二一年九月九日

猪口蹄疫O型病毒样颗粒疫苗一类证书

Class I Certificate for Porcine Foot-and-Mouth Disease Type O Virus-Like Particle Vaccine

中华人民共和国

新兽药注册证书

证号：（2021）新兽药证字 57 号

新兽药名称：牛口蹄疫O型病毒样颗粒疫苗

注册分类：一类

研制单位：中国农业科学院兰州兽医研究所、华宇生物科技（腾冲）有限公司、中农威特生物科技股份有限公司、天津威特生物医药有限责任公司、华派生物工程集团有限公司

根据《兽药管理条例》，该兽药符合规定，准予注册，特发此证。

发证日期：二〇二一年九月九日

牛口蹄疫O型病毒样颗粒疫苗一类证书

Class I Certificate of Foot-and-Mouth Disease O-type Virus-like Particle Vaccine for Cattle

中华人民共和国

新兽药注册证书

证号：（2024）新兽药证字 81 号

新兽药名称：猪口蹄疫病毒O型、A型二价病毒样颗粒疫苗

注册分类：二类

研制单位：中国农业科学院兰州兽医研究所、华宇生物科技（腾冲）有限公司、中农威特生物科技股份有限公司、天津威特生物医药有限责任公司、华派生物技术（集团）股份有限公司、金宇保灵生物药品有限公司

根据《兽药管理条例》，该兽药符合规定，准予注册，特发此证。

发证日期：二〇二四年十二月三日

中华人民共和国

新兽药注册证书

证号：（2025）新兽药证字 17 号

新兽药名称：牛口蹄疫病毒O型、A型二价病毒样颗粒疫苗

注册分类：一类

研制单位：中国农业科学院兰州兽医研究所、华宇生物科技（腾冲）有限公司、中农威特生物科技股份有限公司、天津威特生物医药有限责任公司、华派生物技术（集团）股份有限公司

根据《兽药管理条例》，该兽药符合规定，准予注册，特发此证。

发证日期：二〇二五年三月二十一日

猪口蹄疫O型、A型二价VLPs疫苗、牛口蹄疫OA二价VLPs疫苗。

Bivalent VLPs vaccine against porcine foot-and-mouth disease type O and type A, and bivalent VLPs vaccine against bovine foot-and-mouth disease type O and type A.

PART 2

口蹄疫VLPs的组装
Assembly of Foot-and-Mouth Disease VLPs

01

口蹄疫病
Foot-and-mouth disease
毒样颗粒的定量分析
Quantitative analysis of toxic particles

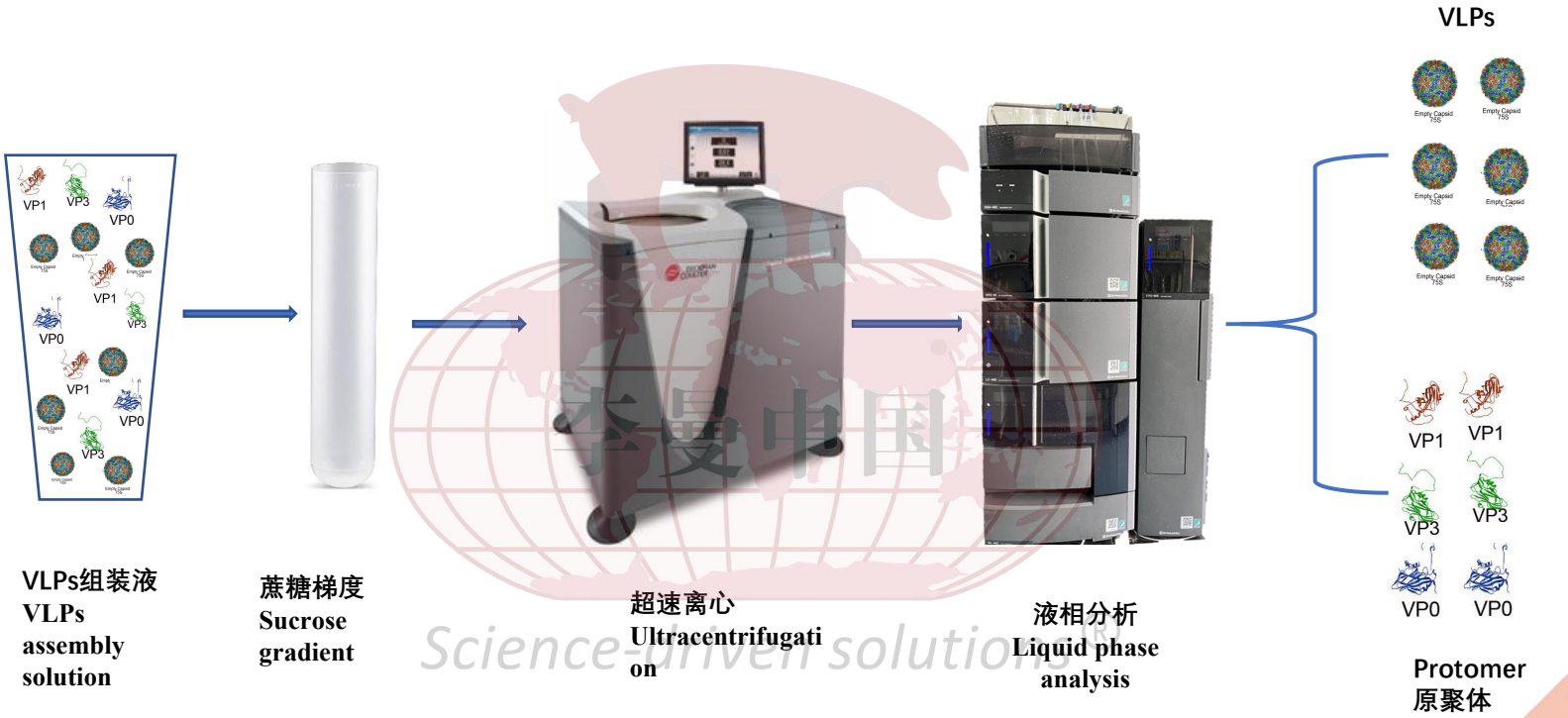


图5 口蹄疫VLPs分离流程图

Figure 5. Flowchart of FMD VLPs isolation

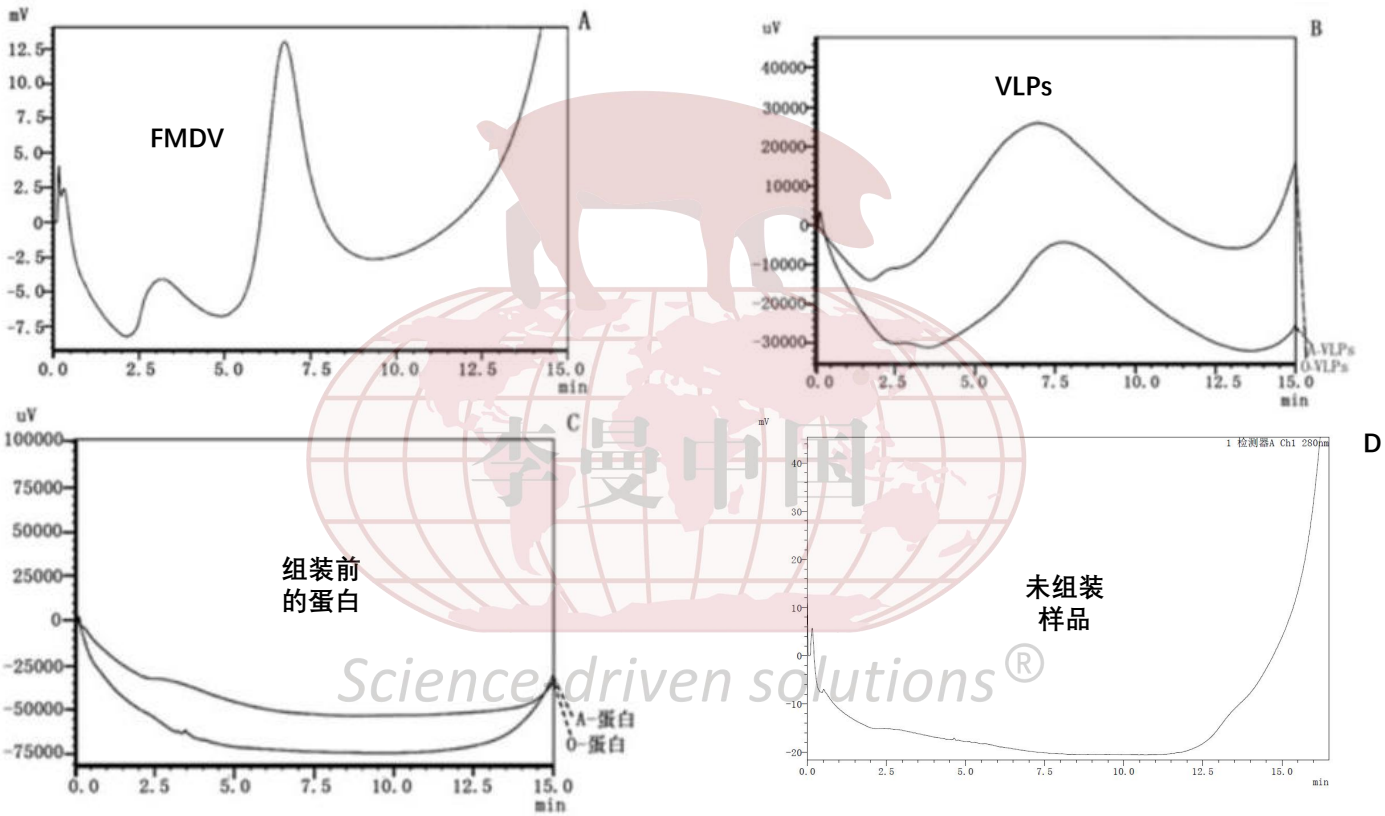


图1 VLPs的蔗糖密度梯度离心结果

Figure 1. Results of sucrose density gradient centrifugation of VLPs

VLPs的出峰时间稍晚与FMDV，由于人工组装的特点，VLPs的峰形比较舒缓。The peak time of VLPs is slightly later than that of FMDV. Due to the characteristics of artificial assembly, the peak shape of VLPs is relatively smooth.

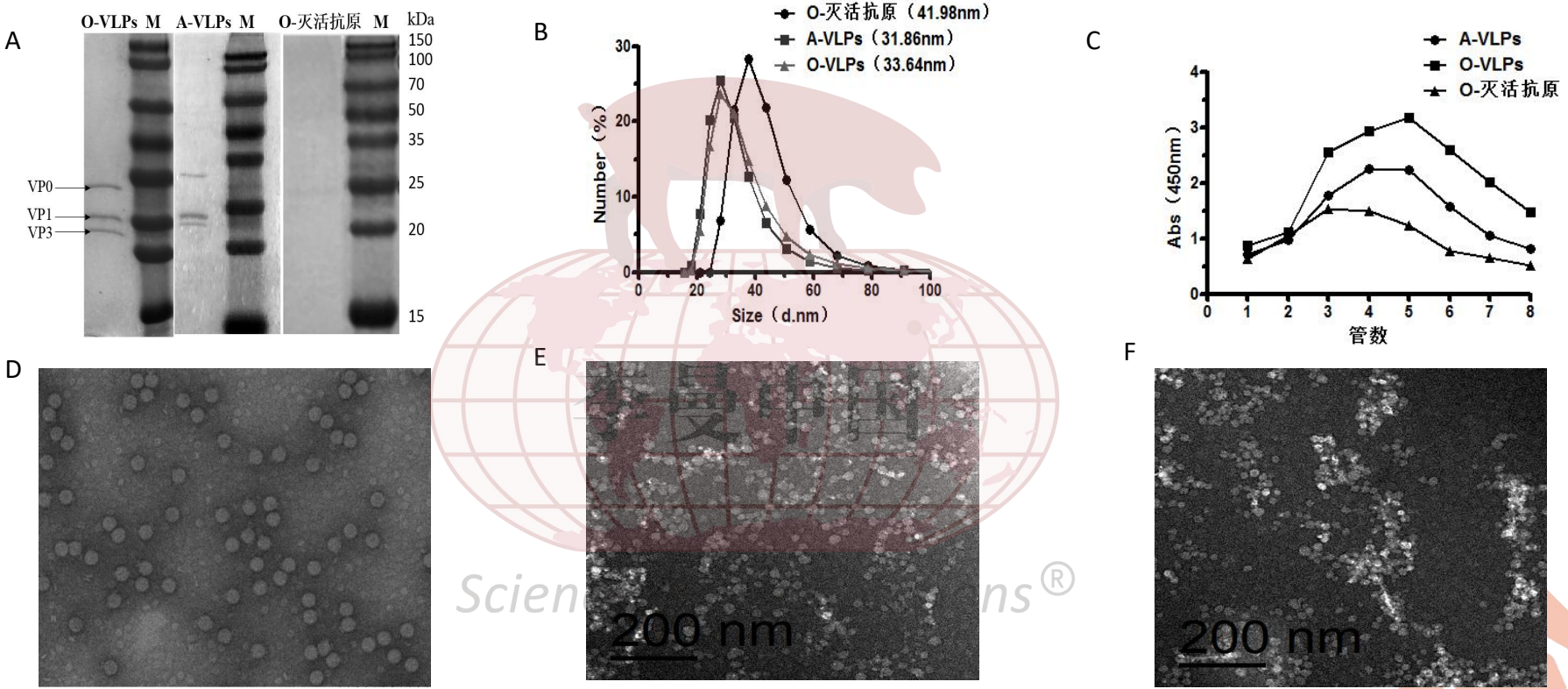


图2 VLPs的蔗糖密度梯度离心收集峰鉴定结果

Figure 2. Identification results of VLPs collected by sucrose density gradient centrifugation

VLPs的收集峰出现口蹄疫病毒的三条目的带，且DLS和电镜检测到大小30nm左右的颗粒

The collection peak of VLPs showed three bands of foot-and-mouth disease virus, and DLS and electron microscopy detected particles with a size of about 30 nm

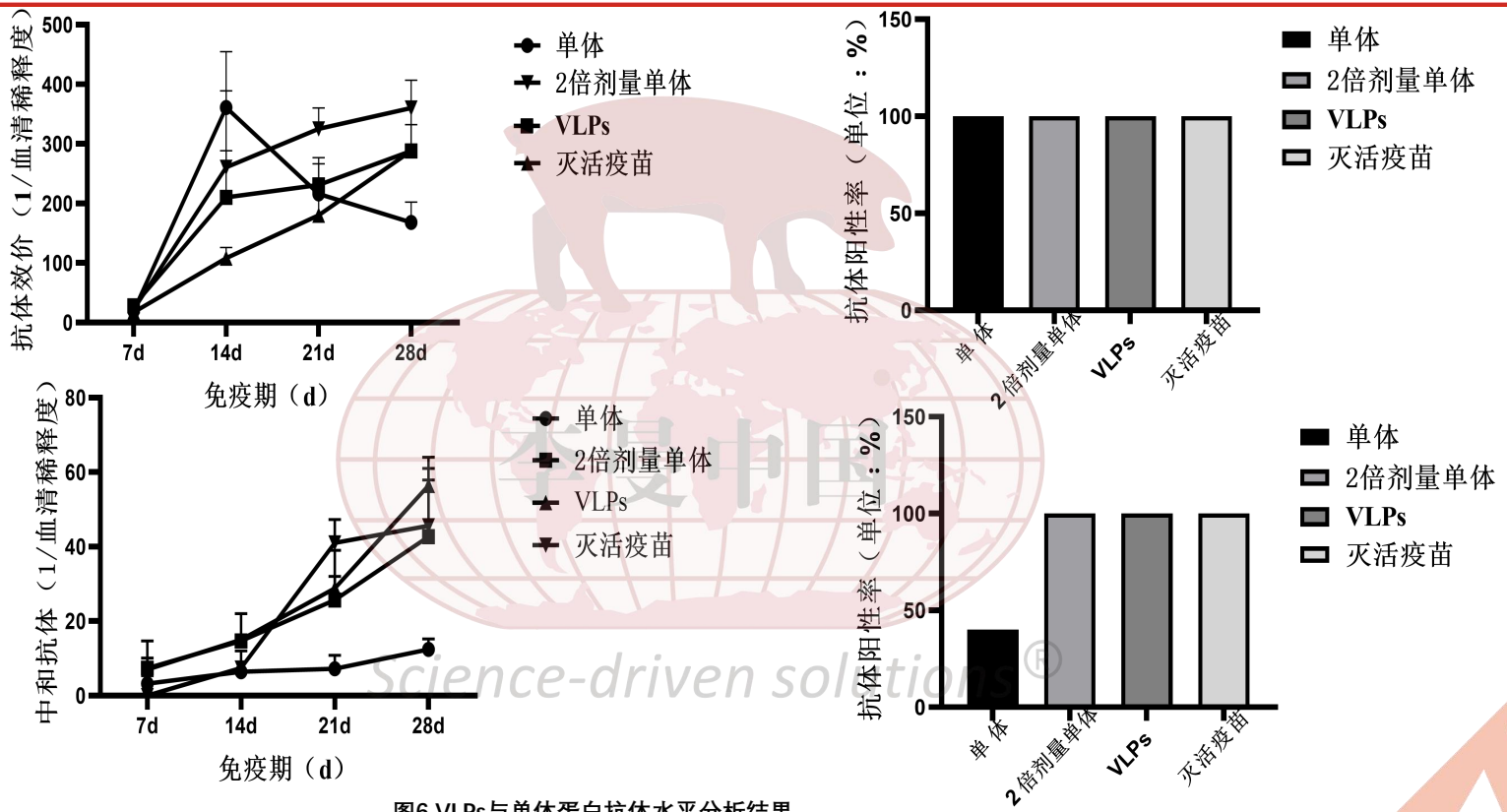


图6 VLPs与单体蛋白抗体水平分析结果

Figure 6 Analysis results of VLPs and monomeric protein antibody levels

VLPs诱发的免疫反应更持久，可诱发高水平特异性抗体和中和抗体；单体诱发的免疫反应持续期短，且诱发中和抗体的能力不足。

The immune response induced by VLPs is more durable, capable of eliciting high levels of specific and neutralizing antibodies; the immune response induced by monomers is short-lived and lacks the ability to induce neutralizing antibodies.

02

口蹄疫病
Foot-and-mouth disease
毒样颗粒组装环境
Environment for assembling VLPs

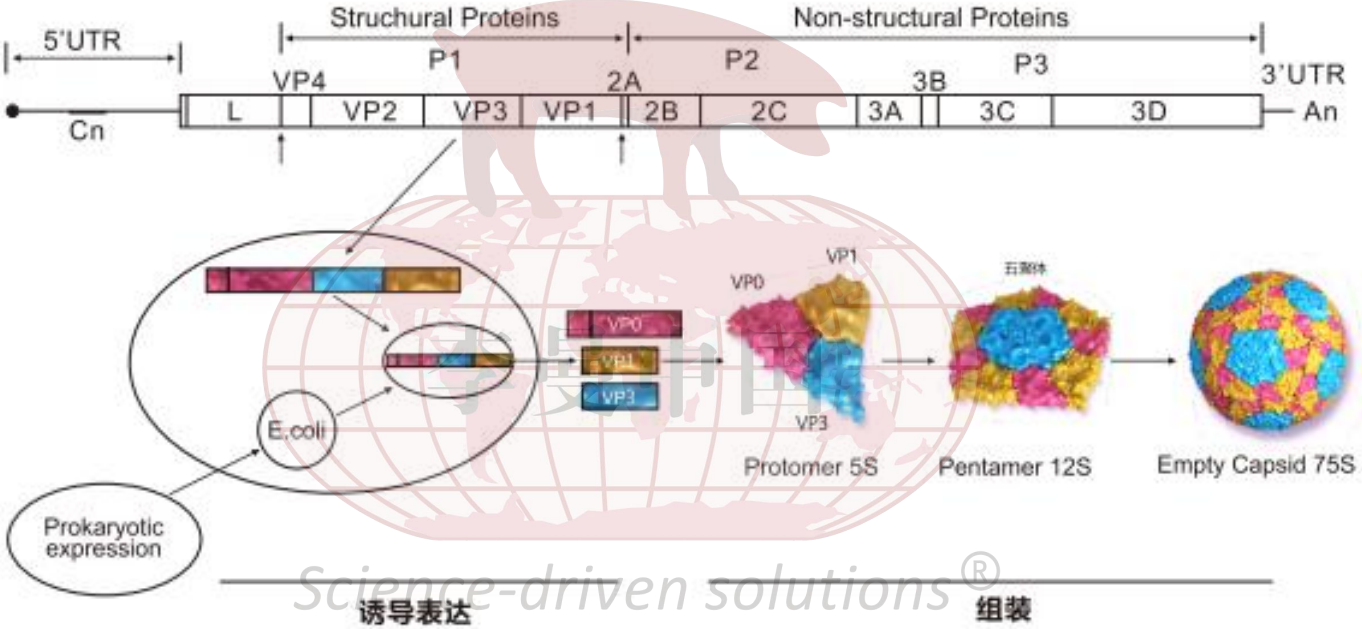


图1 口蹄疫病毒样颗粒组装模式图

Figure 1. Assembly model of foot-and-mouth disease virus-like particles

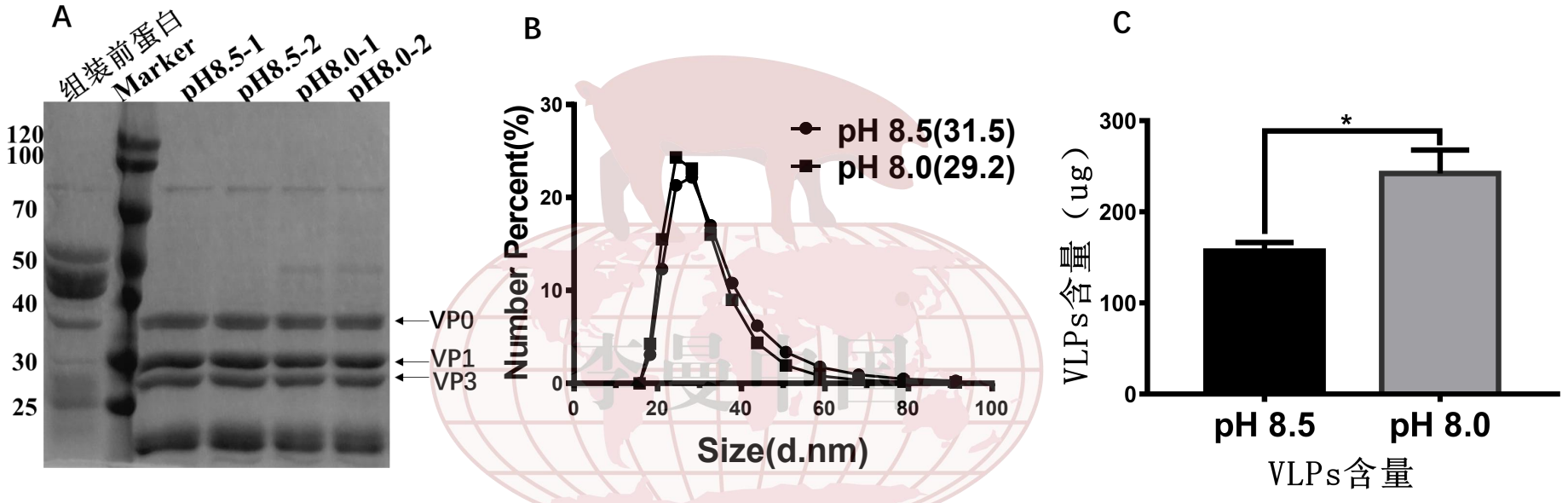


图8 组装液pH对VLPs组装的影响

Figure 8 Effect of assembly solution pH on VLPs assembly

A. SDS-PAGE analysis results; B. DLS analysis results; C. VLPs content detection results

A. SDS-PAGE分析结果；B. DLS分析结果；C. VLPs含量检测结果

口蹄疫病毒pH值耐受范围较窄，而病毒样颗粒的组装试验显示：组装液在pH8.0的条件下组装率明显高于pH8.5

The pH tolerance range of foot-and-mouth disease virus is relatively narrow, and the assembly experiment of virus-like particles shows that the assembly rate of the assembly solution at pH 8.0 is significantly higher than that at pH 8.5

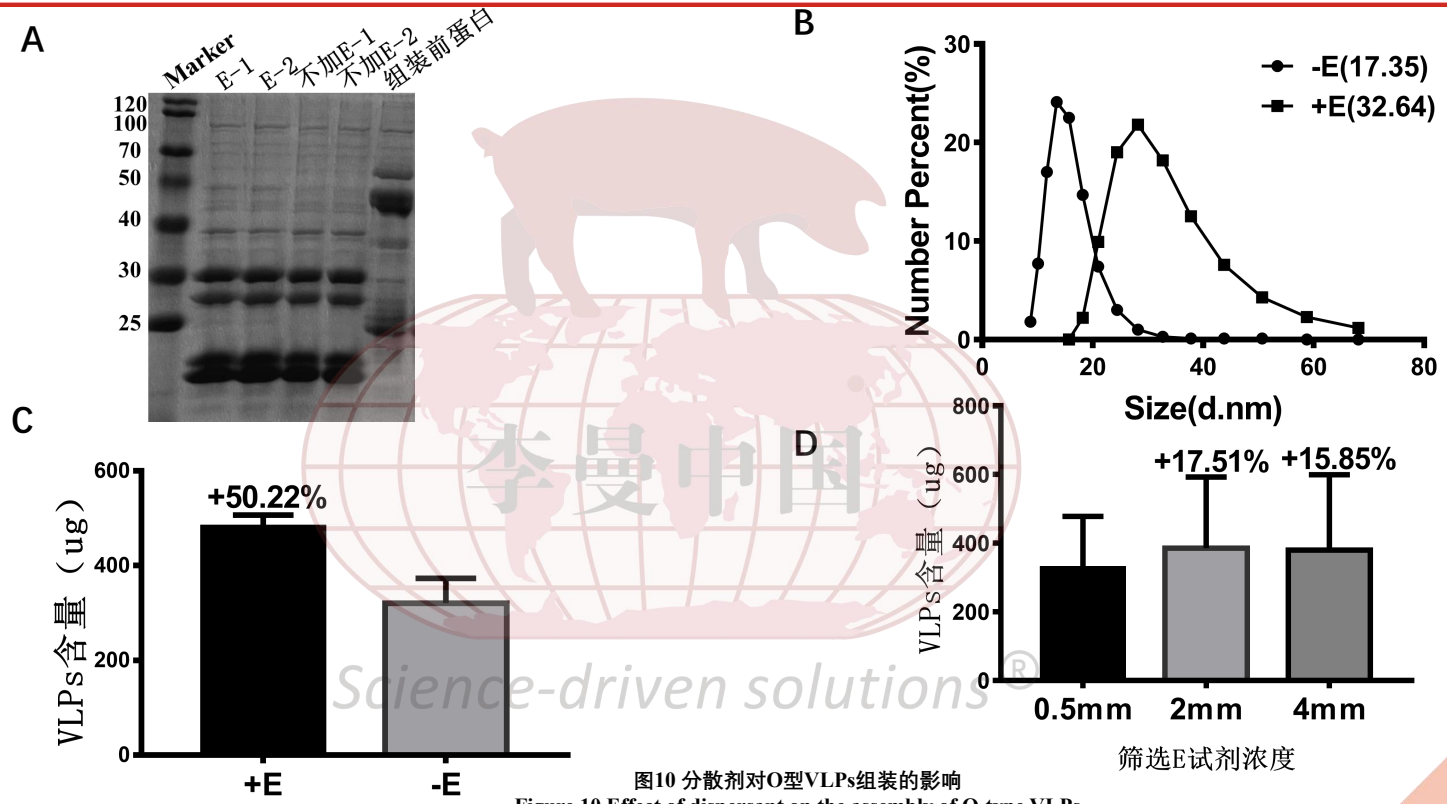


图10 分散剂对O型VLPs组装的影响

Figure 10 Effect of dispersant on the assembly of O-type VLPs

A. SDS-PAGE results; B. DLS results; C. VLPs content detection results; D. Effect of E reagent concentration on VLPs assembly rate

A. SDS-PAGE结果；B. DLS结果；C. VLPs含量检测结果；D. E试剂浓度对VLPs组装率的影响

在纯化蛋白中加入分散试剂可明显提高O型VLPs的组装率

Adding dispersing agents to purified proteins can significantly increase the assembly rate of O-type VLPs

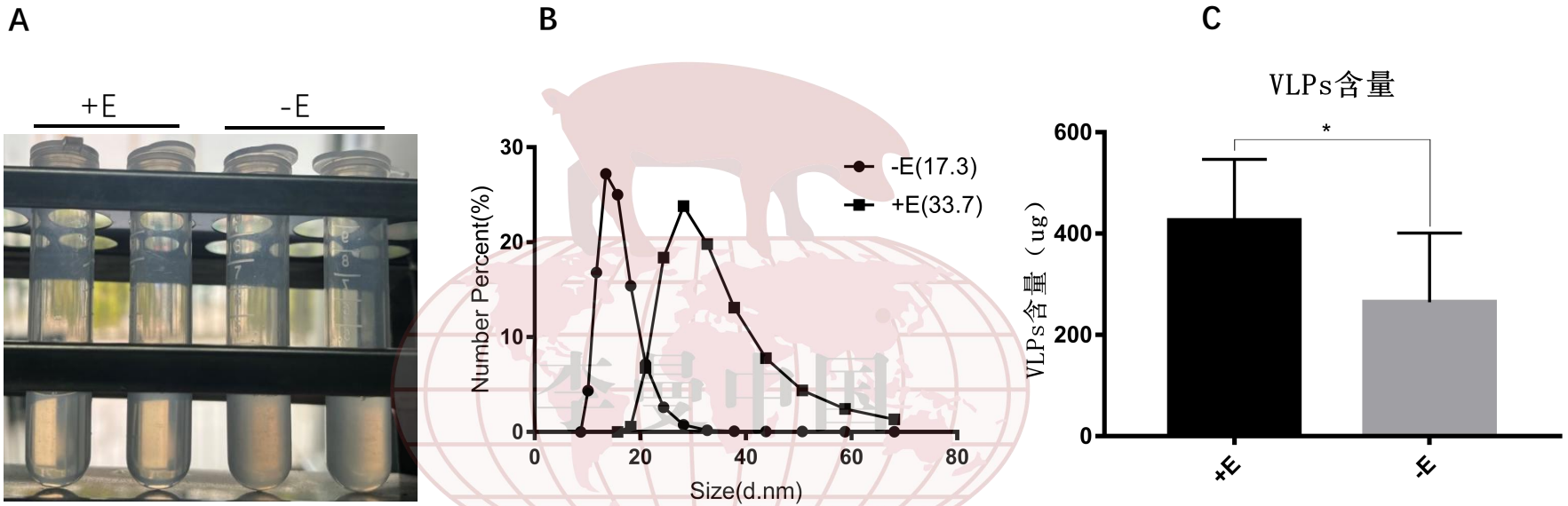


图11 分散剂对A型VLPs组装的影响

A. 浊度对比效果图；B. DLS结果；C. VLPs含量检测结果

Figure 11 Effect of dispersant on the assembly of type A VLPs

A. Turbidity comparison effect diagram; B. DLS results; C. VLPs content detection results

在纯化蛋白中加入分散试剂亦可明显提高A型VLPs的组装率，且A型口蹄疫病毒结构蛋白的聚集明显比O型严重

Adding dispersing agents to the purified protein can also significantly increase the assembly rate of type A VLPs, and the aggregation of type A foot-and-mouth disease virus structural proteins is significantly more severe than that of type O

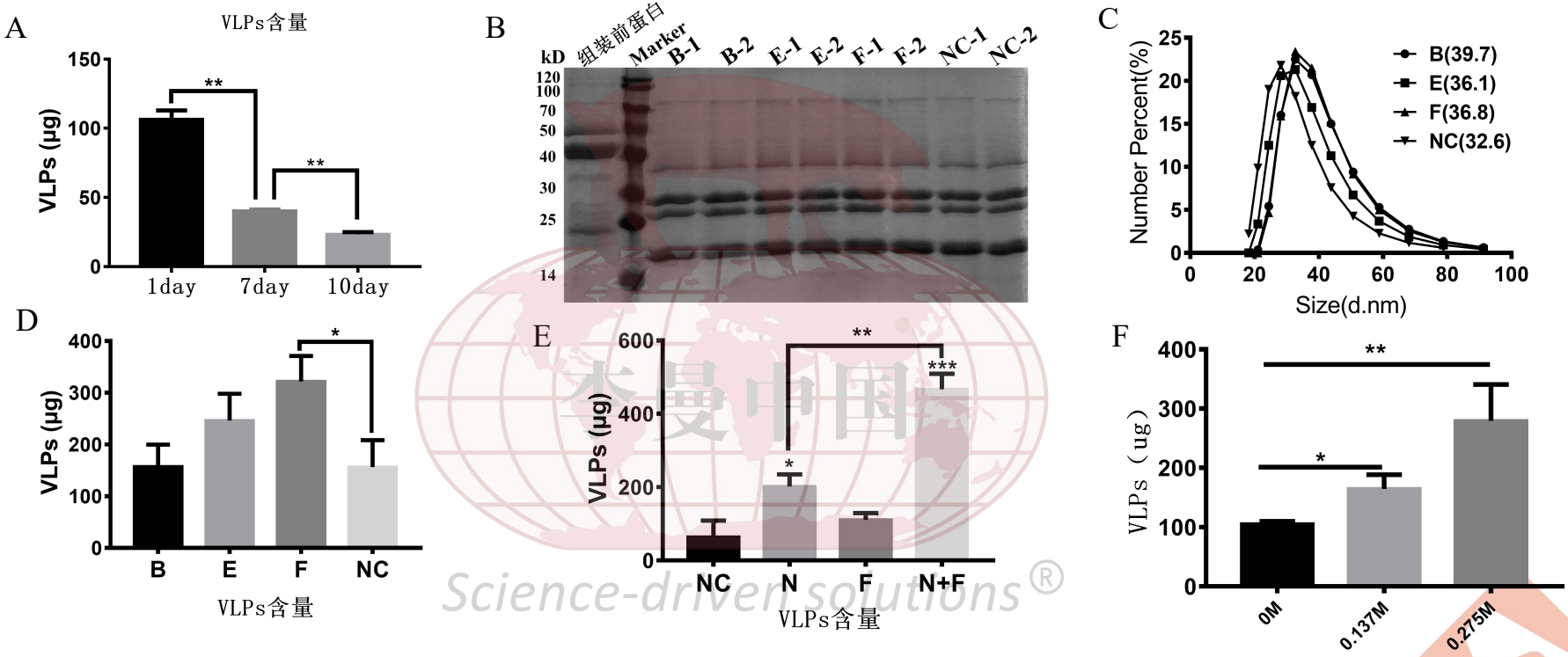


图13 F试剂对O型VLPs组装的影响分析结果

Figure 13 Analysis results of the effect of F reagent on the assembly of O-type VLPs

F试剂可稳定VLPs结构，和N试剂共用时可提高VLPs的组装率

F reagent can stabilize the structure of VLPs, and when used together with N reagent, it can increase the assembly rate of VLPs

- 在组装后的VLPs中添加不同浓度的B试剂，放置16h后检测，VLPs含量0.05%>0.03%>0
- Add different concentrations of B reagent to the assembled VLPs, and detect after 16 hours. The VLPs content is 0.05%>0.03%>0

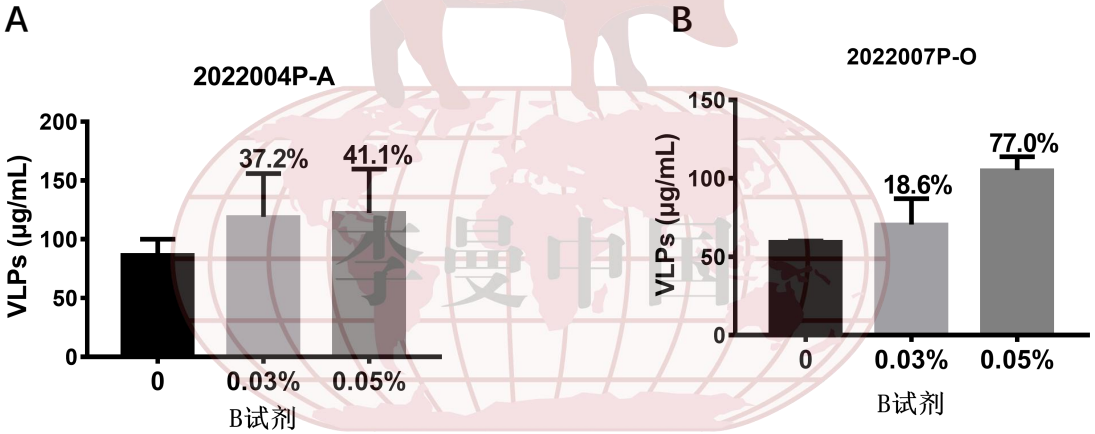
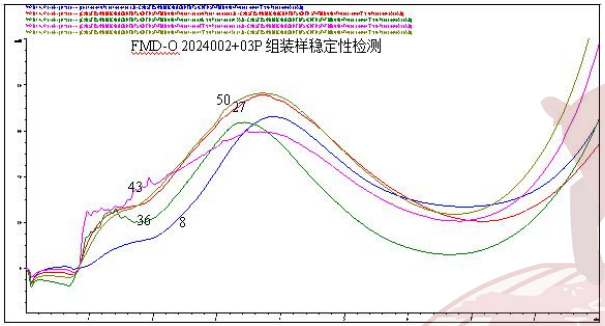


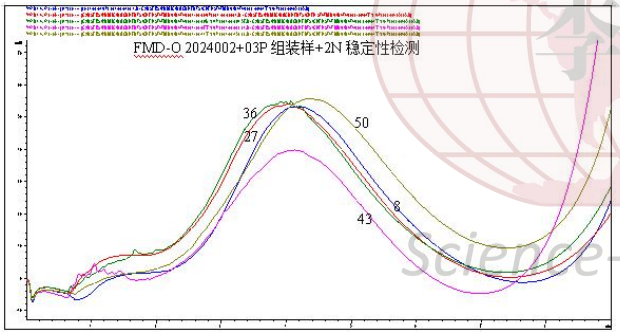
图14 B试剂对O型VLPs组装的影响分析结果

Figure 14 Analysis results of the effect of B reagent on the assembly of O-type VLPs

结果表明VLPs中添加B试剂能显著提高VLPs的含量

The results showed that the addition of B reagent to VLPs significantly increased the content of VLPs





Stabilization of Human Papillomavirus Virus-Like Particles by Non-Ionic Surfactants

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ABSTRACT: Human papillomavirus (HPV) virus-like-particles (VLPs) produced by recombinant expression systems are promising vaccine candidates for prevention of cervical cancers as well as genital warts. At high protein concentrations, HPV VLPs, comprised of the viral capsid protein L1 and expressed and purified from yeast, are protected against detectable aggregation during preparation and storage by high concentrations of NaCl. At low protein concentrations, however, high salt concentration alone does not fully protect HPV VLPs from aggregation. Moreover, the analytical analysis of HPV VLPs proved to be a challenge due to surface adsorption of HPV VLPs to storage containers and cuvettes. The introduction of non-ionic surfactants into HPV VLP aqueous solutions provides significantly enhanced stabilization of HPV VLPs against aggregation upon exposure to low salt and protein concentration, as well as protection

- VLPs在组装或放置过程中会出现聚集，聚集会使组装率下降，且会使VLPs不稳定
- VLPs may aggregate during assembly or placement, which can reduce the assembly rate and destabilize the VLPs
- 及免疫原性下降或丧失。 and decreased or lost immunogenicity.

表1　　猪口蹄疫病毒O型VLPs疫苗的免疫攻毒保护统计结果

Table 1: Statistical results of immune challenge protection of porcine foot-and-mouth disease virus type O VLPs vaccine

疫苗批号	免疫剂量	攻毒毒株	攻毒剂量	试验猪头数	保护比例	PD_{50}/头份
原始抗原	1 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	5/5	5.2
	1/3 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	5/5	
	1/9 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	0/5	
处理 1	1 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	5/5	15.59
	1/3 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	5/5	
	1/9 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	5/5	
处理 2	1 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	5/5	9.0
	1/3 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	4/5	
	1/9 头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	3/5	
对照组	-	O/MYA98/BY/2010	1000ID_{50}/3mL	2	0/2	-

攻毒保护试验结果显示：聚集会降低VLPs的免疫原性，抑制聚集会提高VLPs的免疫原性，但过量的抑制会破坏免疫原性。

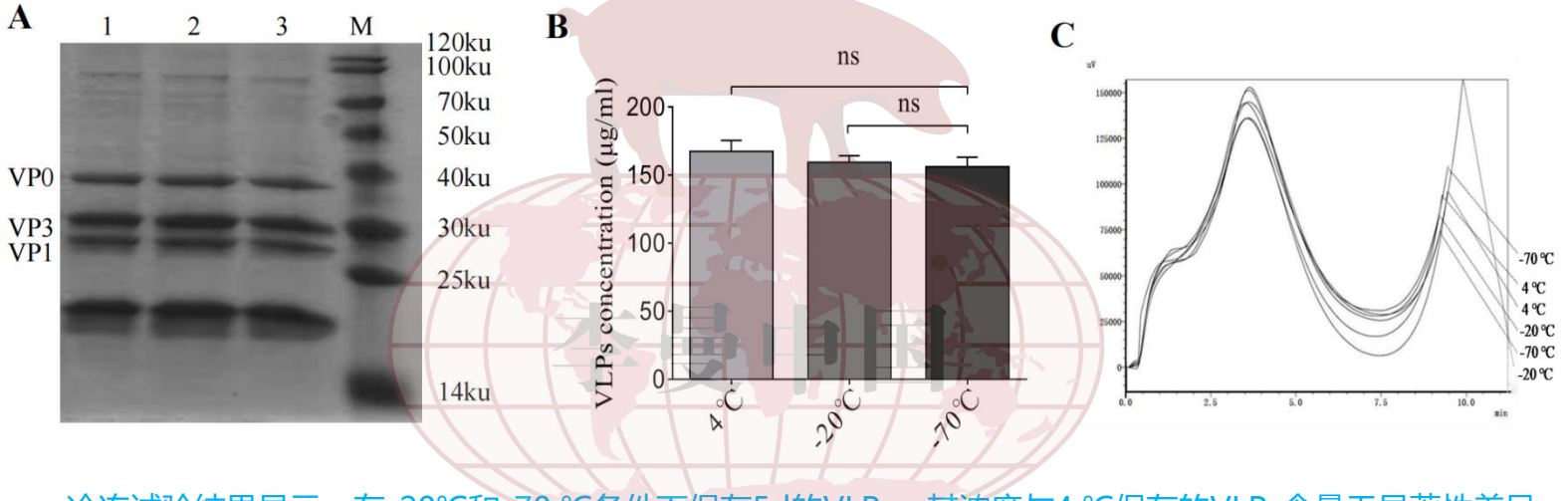
The results of the antiviral protection test showed that aggregation reduces the immunogenicity of VLPs, while inhibiting aggregation can enhance the immunogenicity of VLPs, but excessive inhibition can destroy the immunogenicity.

03

口蹄疫VLPs的稳定性

Stability of Foot-and-Mouth Disease VLPs

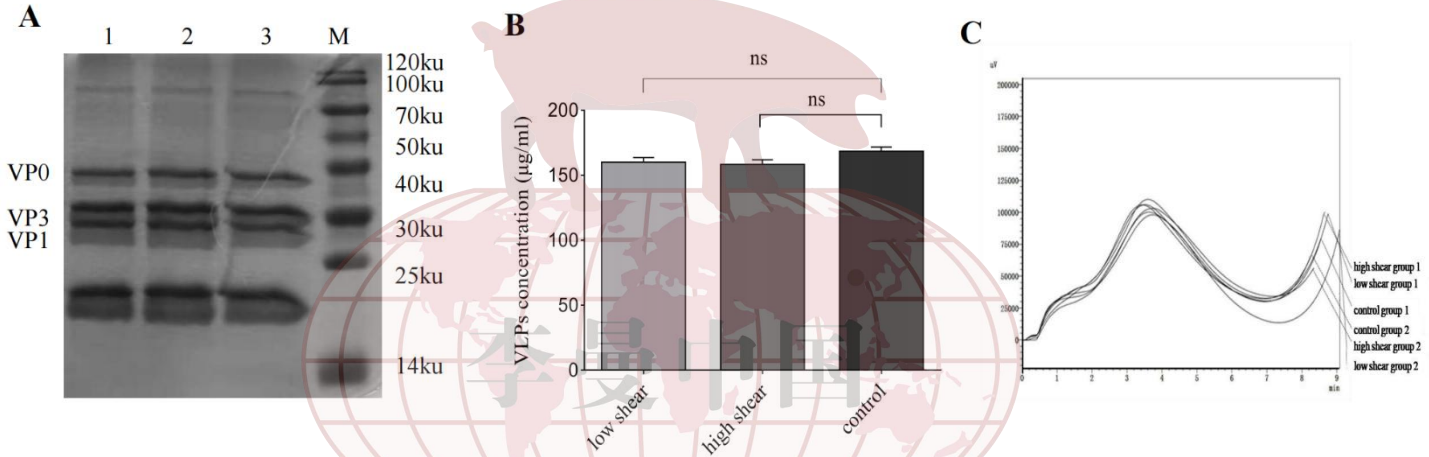
VLPs对冷冻耐受性



冷冻试验结果显示：在-20℃和-70 ℃条件下保存5d的VLPs，其浓度与4 ℃保存的VLPs含量无显著性差异，且蔗糖密度梯度的峰型重叠性好，表明VLPs对冷冻具有一定的耐受性。

The results of the freeze test showed that there was no significant difference in the concentration of VLPs stored at -20℃ and -70℃ for 5 days compared to those stored at 4℃. Additionally, the peak overlap of the sucrose density gradient was good, indicating that VLPs have a certain degree of tolerance to freezing.

VLPs对剪切力的抵抗性



机械剪切结果显示：以3000rpm/min和300rpm/min的转速对VLPs剪切15min，VLPs浓度与4 ℃静置保存的VLPs含量无显著性差异，且蔗糖密度梯度的峰型重叠性好，表明VLPs具有一定的机械抵抗性。

The mechanical shear results showed that there was no significant difference in VLPs concentration between VLPs sheared at 3000 rpm/min and 300 rpm/min for 15 minutes and VLPs stored at 4°C. The peak overlap of the sucrose density gradient was good, indicating that VLPs had certain mechanical resistance.

PART 3

口蹄疫VLPs的免疫特点
Immunological characteristics of foot-and-mouth disease VLPs

01

口蹄疫VLPs疫苗免疫力的产生

Immunity generation of foot-and-mouth disease VLPs vaccine

表1 口蹄疫VLPs疫苗不同时间免疫后抗体及攻毒发病情况统计表

Table 1 Statistics of antibody and challenge incidence after immunization with foot-and-mouth disease VLPs vaccine at different times

免疫背景	试验分组	猪号	免疫时间	攻毒后观察记录										
				0	1	2	3	4	5	6	7	8	9	保护率
				0型抗体	发病	发病	发病	发病	发病	发病	发病	发病	发病	
猪OA二价VLPs 2024003	免疫第3天	008	2024.11.02	<1:16		上蹄								0/5
		012		<1:16	上蹄									
		001		<1:16		上蹄								
		006		<1:16			上蹄							
		005		<1:16		上蹄								
	免疫第7天	004	2024.10.29	1:22		上蹄								2/5
		013		1:45										
		010		1:22		上蹄								
		017		<1:16		上蹄								
		011		1:22										
	免疫第14天	003	2024.10.22	1:22										5/5
		009		1:22										
		014		1:720										
		015		1:1440										
		016		1:360										
	对照	007		<1:16		上蹄								0/2
		002		<1:16	上蹄									

紧急免疫后，3天、7天和14天的抗体阳性率何保护率分别为0%、0%、60%及0%、40%和100%。

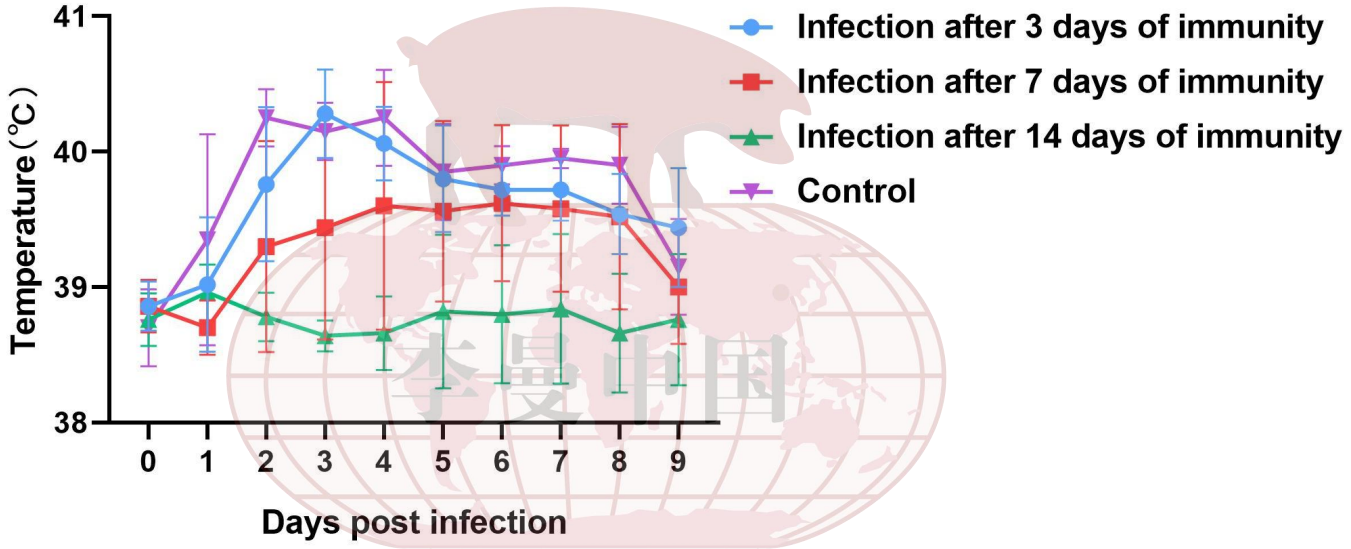
After emergency immunization, the antibody positive rates and protection rates at 3 days, 7 days, and 14 days were 0%, 0%, 60%, and 0%, 40%, and 100%, respectively.

表9　3ABC抗体检测结果

免疫背景	分组	编号	3ABC抗体阳性					保护率
			0	3	5	7	9	
猪口蹄疫O型、A型二价病毒样颗粒疫苗	免疫后3天攻毒	008	-	-	-	+	+	0
		012	-	-	+	+	+	
		001	-	-	-	+	+	
		006	-	-	+	+	+	
		005	-	-	+	+	+	
	免疫后7天攻毒	004	-	-	-	-	-	40%
		013	-	-	-	-	-	
		010	-	-	-	+	+	
		017	-	-	+	+	+	
		011	-	-	-	+	+	
	免疫后14天攻毒	003	-	-	-	-	-	100%
		009	-	-	-	-	-	
		014	-	-	-	-	-	
		015	-	-	-	-	-	
		016	-	-	-	-	-	
	对照组	007	-	-	-	+	+	0
		002	-	-	-	+	+	

攻毒后3ABC抗体检测结果显示，未发病猪只的3ABC抗体均为阴性，表明病毒被完全中和，不能复制。
The 3ABC antibody test results after virus challenge showed that the 3ABC antibodies of the non-infected pigs were all negative, indicating that the virus was completely neutralized and could not replicate.

体温变化



紧急免疫攻毒后，14天免疫动物的体温在整个攻毒期间均正常；7天免疫组的动物虽只有40%保护，但体温也显著低于对照组和3天免疫组。

Following an emergency immunization challenge, the body temperature of animals immunized for 14 days remained normal throughout the entire challenge period. Although the 7-day immunization group only achieved 40% protection, their body temperature was significantly lower than that of the control group and the 3-day immunization group.

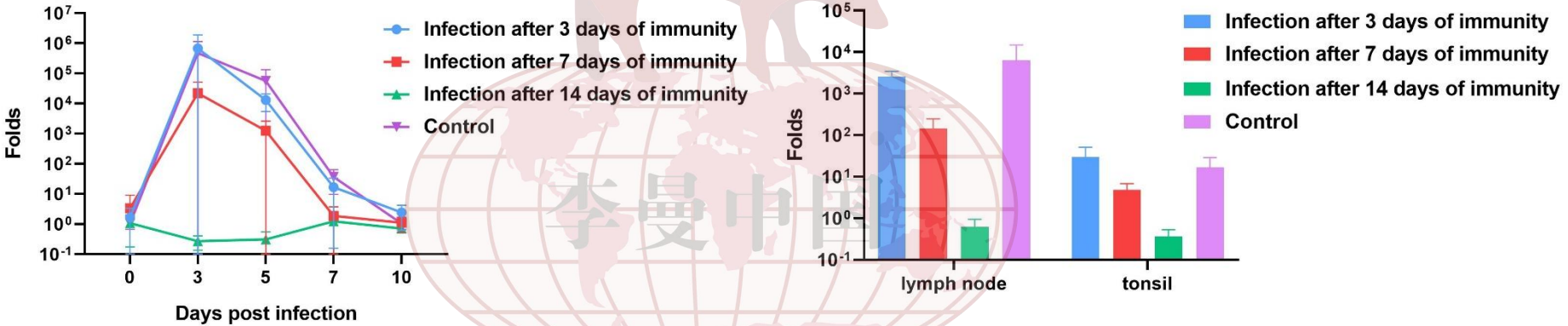


图13 紧急免疫后血清和组织中FMDV含量的变化

Figure 13 Changes in FMDV content in serum and tissues after emergency immunization

紧急免疫攻毒后，14天免疫动物的血清和组织中FMDV均为阴性；7天免疫组的动物虽只有40%保护，但血清和组织中的病毒含量显著低于对照组和3天免疫组。

After emergency immune challenge, the serum and tissues of animals immunized for 14 days were all negative for FMDV; although only 40% of animals in the 7-day immunization group were protected, the virus content in serum and tissues was significantly lower than that in the control group and the 3-day immunization group.

02

口蹄疫VLPs疫苗免疫特点及持续期

Immunization characteristics and duration of foot-and-mouth disease VLPs vaccine

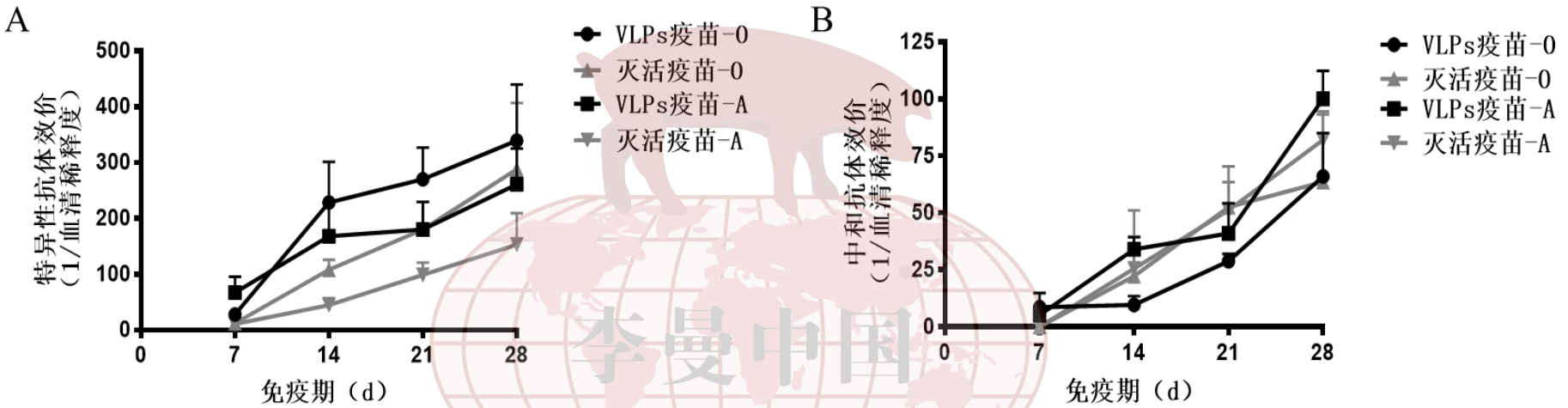


图1 猪口蹄疫O型、A型二价VLPs疫苗与猪全病毒灭活疫苗抗体水平比对结果（猪）

Figure 1 Comparison of antibody levels between bivalent VLPs vaccine against foot-and-mouth disease type O and type A and inactivated whole virus vaccine in pigs

VLPs疫苗与全病毒灭活疫苗免疫猪后抗体水平检测结果显示：VLPs疫苗诱发抗体的产生期明显短与灭活疫苗，14天特异性抗体水平即可达1:64；中和抗体水平不低于灭活疫苗。

The results of antibody level detection after immunizing pigs with VLPs vaccine and whole virus inactivated vaccine showed that the production period of antibodies induced by VLPs vaccine was significantly shorter than that of inactivated vaccine, with a specific antibody level of 1:64 achieved within 14 days; the neutralizing antibody level was not lower than that of inactivated vaccine.

VLPs疫苗与灭活苗免疫效果比对

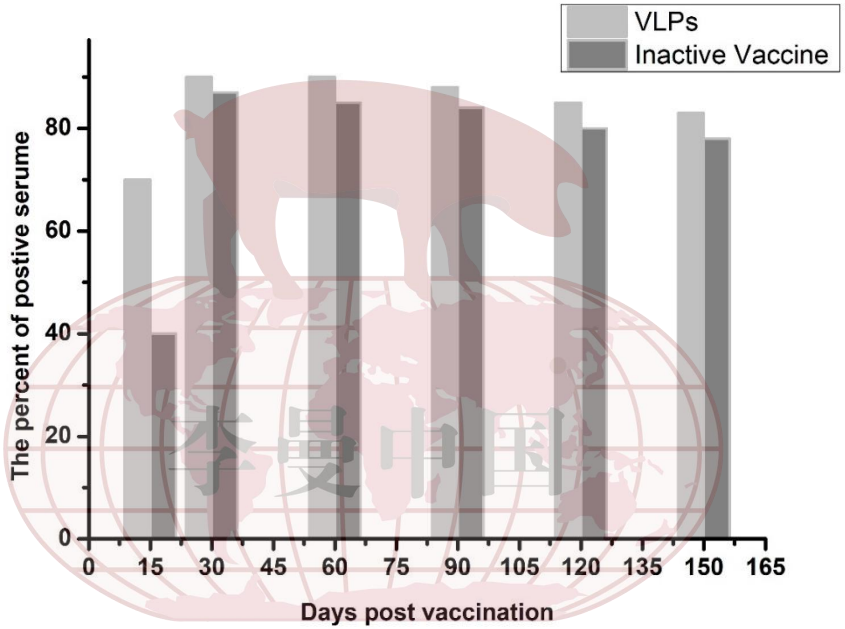


图13 VLPs疫苗与高端灭活苗O型抗体变化趋势对比

Figure 13 Comparison of the change trend of O-type antibody between VLPs vaccine and high-end inactivated vaccine

VLPs疫苗诱发抗体的产生速度要明显快于灭活疫苗，14天70%的抗体转阳，且单次免疫在5个月内抗体水平均不低于灭活疫苗。The production speed of antibodies induced by VLPs vaccine is significantly faster than that of inactivated vaccine, with 70% of antibodies turning positive within 14 days, And the antibody level of single immunization is not lower than that of inactivated vaccine within 5 months.

表5 猪口蹄疫O型VLPs疫苗抗体水平及攻毒情况统计表
Table 5 Statistical table of antibody level and challenge of swine foot-and-mouth disease type O VLPs vaccine

疫苗名称	动物编号	LPB-ELISA抗体水平 0	15dpi	30dpi	60dpi	90dpi	120dpi	150dpi	164dpi	171dpi	发病情况
猪口蹄疫O型病毒样颗粒疫苗	B02	1:8	> 1：256	1:180	1：256	1：256	1：256	1：180	1：180		无
	B08	1:8	> 1：256	> 1：256	1：256	1：256	1：180	1：180	1：90		无
	B26	1:8	> 1：256	> 1：256	1：256	1：256	1：256	1：256	1：128	攻毒	无
	B32	1:8	1:180	> 1：256	1:180	1:180	1:180	1:128	1:90		无
	B39	1:8	1:32	1:90	1:180	1:180	1:90	1:90	1:45		一蹄
	阳性率	0%	77.1%	85.4%	82.6%	80%	76.7%	77.0%	80%	保护率	80%

猪口蹄疫病毒样颗粒疫苗单次免疫后抗体持续期为6个月，免疫6个月后的保护力大于≥80%。
The antibody persistence period of the porcine foot-and-mouth disease virus-like particle vaccine after a single immunization is 6 months, and the protection rate after 6 months of immunization is greater than or equal to 80%.

BG108-7.8-2023

副 本

编号：ZCS230138

检 验 报 告

检品名称 牛口蹄疫病毒O型、A型二价病毒样颗粒疫苗

供样单位 华宇生物科技（腾冲）有限公司

检验类别 注册检验

中国兽医药品监察所

BG108-7.8-2023

中国兽医药品监察所

检 验 报 告

编号：ZCS230138

检品名称	牛口蹄疫病毒O型、A型二价病毒样颗粒疫苗		
商 品 名	/	规 格	40ml/瓶
批 号	2023003	包 装	塑料瓶
生产单位	华宇生物科技（腾冲）有限公司	有效期至	2025年03月02日
供样单位	华宇生物科技（腾冲）有限公司	保存条件	2℃-8℃保存
检验类别	注册检验	检品数量	80瓶
检验依据	申报标准	收检日期	2023年12月25日
检验项目	安全检验，效力检验		
检验地点	北京市海淀区中关村南大街8号，北京市大兴区生物医药产业基地庆丰西路33号		
检验日期	2023年12月25日至2024年06月03日		
备 注	/		

检验项目	标准规定	检验结果	项目结论
[安全检验]	（1）用小动物检验：豚鼠和小鼠均应不出现因注射疫苗引起的死亡或明显的局部或全身不良反应。 （2）用牛检验：免疫牛均应不出现因注射疫苗引起的明显局部炎症反应（注射部位无红肿、溃疡、结节、肉芽肿等）或全身不良反应（注射后应不发生呼吸困难、呕吐、皮肤和黏膜发绀、站立不稳等），精神、食欲与接种前应无明显变化。接种后与基础体温相比，体温升高应不超过1.0℃；若体温升高超过1.0℃，但稽留不超过2个温次，判为合格。	（1）用小动物检验：豚鼠2/2健活，均未出现因注射疫苗引起的死亡和明显的局部和全身不良反应。小鼠5/5健活，均未出现因注射疫苗引起的死亡和明显的局部和全身不良反应。 （2）用牛检验：接种牛2/2健活，均未出现因注射疫苗引起的明显局部炎症反应和全身不良反应，精神、食欲与接种前均无明显变化，接种后与基础体温相比，体温升高均不超过1.0℃。	符合规定
[效力检验]	对照牛应全部发病，免疫牛仅在舌面出现水泡或溃疡，而其它部位无病变时，判为保护；	O型对照牛2/2发病，两头均四蹄溃疡，每头份疫苗含O型口蹄疫≥13.9PD50；	符合规定

编号：ZCS230138

检验项目	标准规定	检验结果	项目结论
	除舌面以外任何一部位出现典型口蹄疫水泡或溃疡时，判为不保护，每头份疫苗应至少含O型、A型口蹄疫各6PD50。	A型对照牛2/2发病，一头牛四蹄溃疡，另一头牛三蹄溃疡，A型口蹄疫≥15.5PD50。	
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检验结论：本品按申报标准检验上述项目，结果符合规定。

编 制： 审 核：李 宁 批 准：

2024年06月03日

牛口蹄疫O型、A型二价病毒样颗粒疫苗：O型每头份含13.9 PD_{50}；A型每头份含15.5 PD_{50}

Bivalent virus-like particle vaccine for foot-and-mouth disease of cattle, types O and A: Each dose contains 13.9 PD_{50} for type O and 15.5 PD_{50} for type A

猪 OA二价VLPs 疫苗复核检验

BG108-7.8-2023

副 本

编号：ZCS230134

检 验 报 告

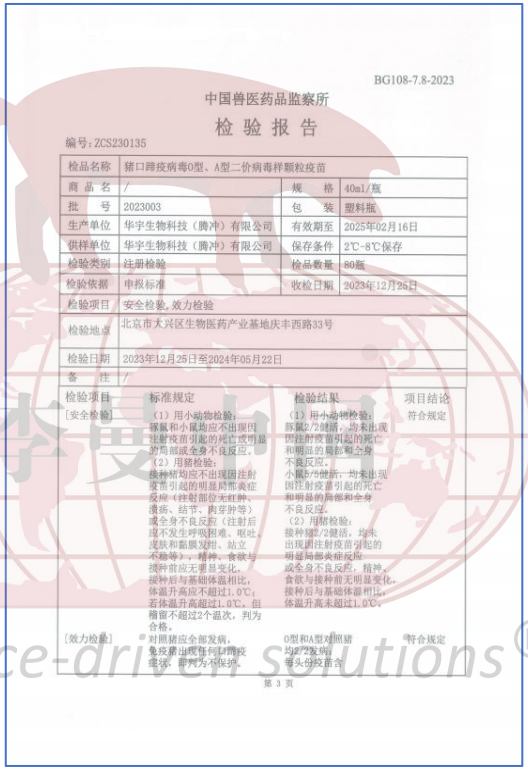
检品名称 猪口蹄疫病毒O型、A型二价病毒样颗粒疫苗

供样单位 华宇生物科技（腾冲）有限公司

检验类别 注册检验

中国兽医药品监察所

第 1 页



BG108-7.8-2023

中国兽医药品监察所

检 验 报 告

编号：ZCS230135

检品名称	猪口蹄疫病毒O型、A型二价病毒样颗粒疫苗		
商 品 名	/	规 格	40ml/瓶
批 号	2023003	包 装	塑料瓶
生产单位	华宇生物科技（腾冲）有限公司	有效期至	2025年02月16日
供样单位	华宇生物科技（腾冲）有限公司	保存条件	2℃-8℃保存
检验类别	注册检验	检品数量	80瓶
检验依据	申报标准	收检日期	2023年12月25日
检验项目	安全检验，效力检验		
检验地点	北京市大兴区生物医药产业基地庆丰西路33号		
检验日期	2023年12月25日至2024年05月22日		
备 注	/		

检验项目	标准规定	检验结果	项目结论
[安全检验]	（1）用小动物检验：豚鼠和小鼠均应不出现因注射疫苗引起的死亡或明显的局部或全身不良反应。 （2）用猪检验：接种猪均应不出现因注射疫苗引起的明显肝脏炎症反应（注射部位无红肿、溃疡、结节、肉芽肿等）或全身不良反应（注射后应不发生呼吸困难、呕吐、皮肤和黏膜发绀、站立不稳等），精神、食欲与接种前应无明显变化。接种后与基础体温相比，体温升高应不超过1.0℃；若体温升高超过1.0℃，但稽留不超过2个温次，判为合格。	（1）用小动物检验：豚鼠2/2健活，均未出现因注射疫苗引起的死亡和明显的局部和全身不良反应。 小鼠5/5健活，均未出现因注射疫苗引起的死亡和明显的局部和全身不良反应。 （2）用猪检验：接种猪2/2健活，均未出现因注射疫苗引起的明显局部炎症反应或全身不良反应，精神、食欲与接种前无明显变化。接种后与基础体温相比，体温升高未超过1.0℃。	符合规定
[效力检验]	对照猪应全部发病，免疫猪出现任何口蹄疫症状，即判为不保护。	O型和A型对照猪均2/2发病，每头份疫苗含	符合规定

第 3 页

编号：ZCS230135

检验项目	标准规定	检验结果	项目结论
以下空白	每头份疫苗应至少含O型、A型口蹄疫各6PD50。	O型口蹄疫≥14.3PD50、A型口蹄疫≥14.3PD50。	

检验结论：本品按申报标准检验上述项目，结果符合规定。

编 制： 审 核：李 宁 批 准：

2024年05月22日

第 4 页

猪口蹄疫O型、A型二价病毒样颗粒疫苗：O型每头份含14.3 PD_{50}；A型每头份含14.3 PD_{50}

Bivalent virus-like particle vaccine against foot-and-mouth disease in pigs, types O and A: Each dose contains 14.3 PD_{50} for type O and 14.3 PD_{50} for type A

03

口蹄疫VLPs疫苗稳定性

Stability of foot-and-mouth disease VLPs vaccine

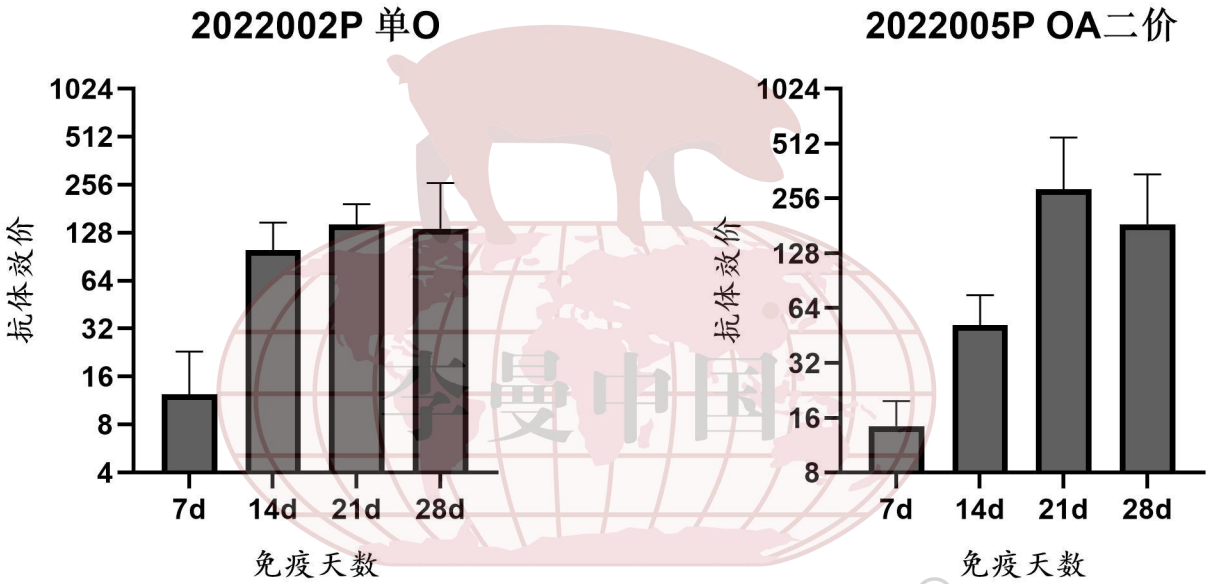


图8 放置9个月VLPs疫苗的抗体检测结果

Figure 8 Antibody detection results of VLPs vaccine placed for 9 months

免疫试验结果显示：放置9个月的口蹄疫病毒样颗粒疫苗免疫60天的架子猪，单次免疫30天后抗体水平合格率100%。。The results of the immune test showed that the 60-day-old pigs immunized with the foot-and-mouth disease virus-like particle vaccine placed for 9 months, The qualified rate of antibody level was 100% after 30 days of single immunization.

表11 口蹄疫O型VLPs疫苗的免疫攻毒保护统计结果

Table 11 Statistical results of immune challenge protection of foot-and-mouth disease type O VLPs vaccine

疫苗批号	免疫剂量	攻毒毒株	攻毒剂量	试验猪头数	保护比例	PD_{50}/头份
2022002	1头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	5/5	9.0
	1/3头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	4/5	
	1/9头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	3/5	
2022005	1头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	4/5	9.0
	1/3头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	3/5	
	1/9头份	O/MYA98/BY/2010	1000ID_{50}/3mL	5	4/5	
对照组	-	O/MYA98/BY/2010	1000ID_{50}/3mL	6	0/6	-

攻毒保护试验结果显示：放置9个月的口蹄疫病毒样颗粒疫苗能仍能保护靶动物抵抗O型强毒株的攻击，保护效力仍达到我国PD_{50}大于6的标准。

The results of the virus attack protection test showed that the foot-and-mouth disease virus like particle vaccine placed for 9 months can still protect target animals against the attack of the O-type virulent strain, and the protective efficacy still meets the standard of PD_{50} greater than 6 in China.

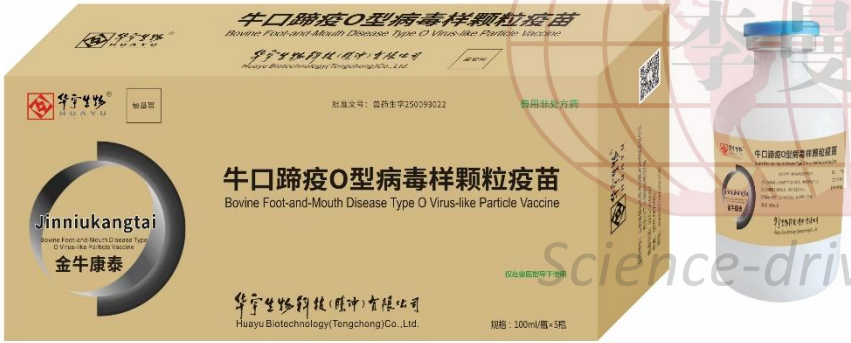
疫苗放置18个月后效力检测
Efficacy test of vaccine after 18 months of storage

序号	疫苗	初始PD_{50}	18个月后PD_{50}
1	01	15.39	9.0
2	02	13.59	10.05

两批疫苗放置18个月后效力均有下降，但两批疫苗PD_{50}均仍 > 6。

After being stored for 18 months, the efficacy of both batches of vaccines decreased, but the PD_{50} of both batches of vaccines remained greater than 6.

FMD VLPs疫苗



四种口蹄疫VLPs疫苗均已上市，VLPs疫苗为新一代疫苗，抗原普广，安全、高效、 可实现感染动物和免疫动物的 精准鉴别，专为口蹄疫净化而生。

Four types of foot-and-mouth disease VLPs vaccines have been launched on the market. VLPs vaccines are a new generation of vaccines with broad antigenicity, safety, high efficiency, and precise differentiation between infected and immune animals. They are specifically designed for the purification of foot-and-mouth disease.

感谢观看！
Thanks for watching!

请各位领导和专家批评指正，并持续关注FMD VLPs疫苗

We kindly request that all leaders and experts provide their critiques and corrections, and continue to monitor the FMD VLPs vaccine

华宇生物科技（腾冲）有限公司